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Contents—Sept., 1954

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ARCHIVES OF PHYSICAL MEDICINE AND REHABILITATION

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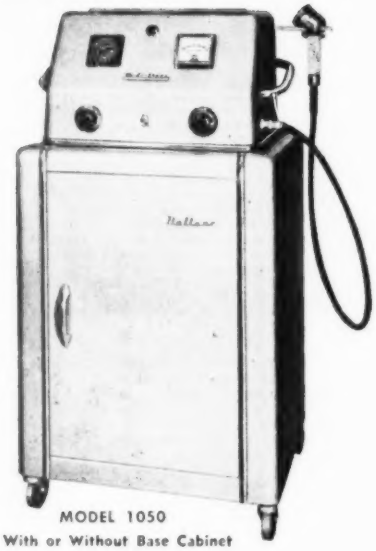

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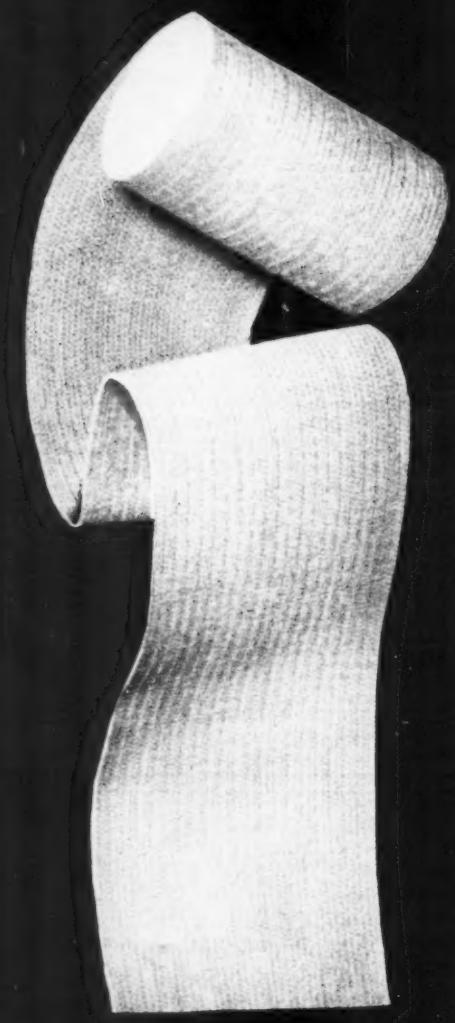

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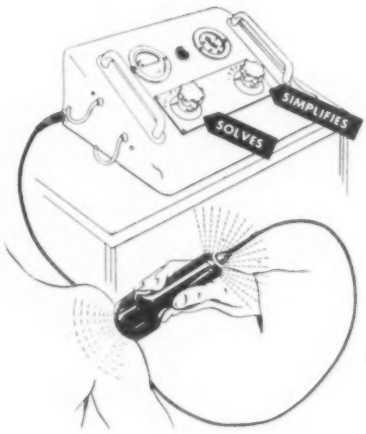

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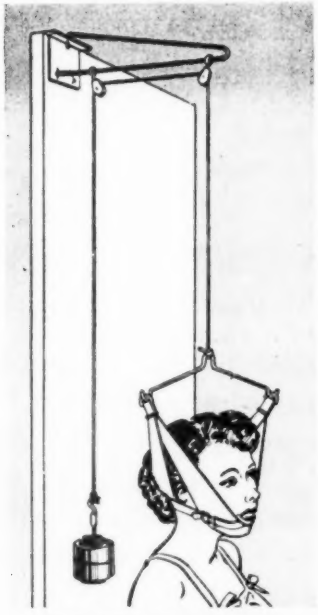

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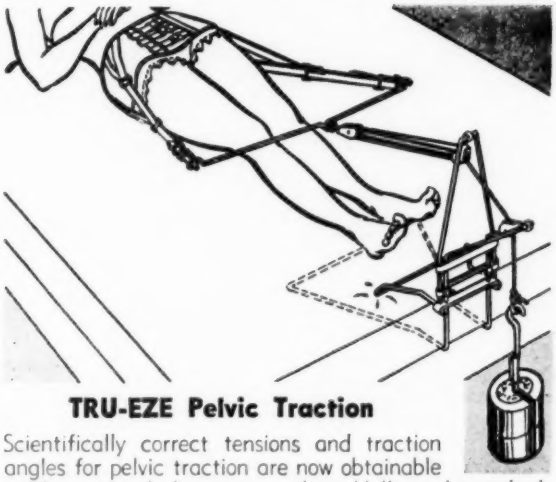

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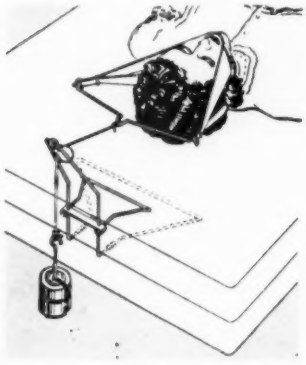

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Histologic Studies Following Exposure of Bone to Ultrasound

Leonard F. Bender, M.D.
Fellow in Physical Medicine and Rehabilitation,
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Joseph M. Janes, M.D.,
Section of Orthopedic Surgery, Mayo Clinic,

and

J. F. Herrick, Ph.D.,
Section of Biophysics,
Mayo Foundation, University of Minnesota,
Rochester, Minn.

The relatively general application of ultrasound in medicine throughout the European countries during recent years has stimulated investigations concerning physiologic and pathologic effects of this new physical agent in the United States. We have been studying the biologic effects of ultrasound on various experimental animals for five years. Perhaps the effect which has been most interesting to us is the selective heating of bone[1,2]. So far as we know there is no other agent which heats bone so effectively. Dangerously high temperatures may be produced in bone cortex and bone marrow in less than two minutes by relatively moderate doses of ultrasound.

It was important to study the histologic changes occurring in bone following exposure to ultrasound. Upon searching the literature for investigations of histologic changes produced in bone, we found only a few pertinent articles[3-6]. This paper reports the results of such studies which we have made on the anesthetized dog.

Ultrasonic waves are those waves in the acoustic spectrum which are beyond the range of the human ear. The standards committee on electro-acoustics states that those frequencies above about 15,000 cycles per second are ultrasonic[7]. Ultrasonic waves differ from the familiar audible waves only in frequency and, therefore, wave length. Other characteristics remain fundamentally the same. The frequencies most generally used thus far for medical therapy are 800 and 1,000 kilocycles per second. The wave lengths in muscle at these two frequencies are 1.92 and 1.54 mm. respectively.

Equipment and Methods

The particular ultrasonic generator used in most of our studies was the Siemens sonostat. The source of ultrasonic waves, a quartz crystal, is housed in the so-called sound or massage head which is situated at one end of a long coaxial cable. The other end of the coaxial cable is connected to a radio-frequency oscillator which generates alternating electric currents having the same frequency as the natural frequency of the quartz crystal. The long coaxial cable permits the freedom of motion of the sound head which is required for the various applications desired in medical therapy. The radiating surface of the ultrasound head was ten square centi-

Read at the Surgical Forum of the American College of Surgeons, New York, September 22 to 25, 1952.

Abridgment of portion of thesis submitted by Dr. Bender to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Physical Medicine and Rehabilitation.

We wish to express our appreciation for the laboratory facilities which were put at our disposal for preparing the histologic slides, and also for the valuable suggestions and constructive criticisms given us by the following members of the Section of Surgical Pathology: Dr. J. R. McDonald, Dr. D. C. Dahlin and Dr. C. J. Dawe. We wish also to express our gratitude to Mrs. Ella May Boughner for the excellent technical assistance rendered in the preparation of the histologic slides.

meters. The ultrasonic power generated by the sound head may be measured by inserting the sound head properly into the Siemens power meter, which is calibrated to read in watts.

Two series of dogs were used in these investigations. In the first series, which included sixteen dogs, we wished to observe the temperatures produced during the exposure to ultrasound. Surgical procedures were required for inserting the thermocouples. It was necessary to drill holes in the femurs to permit insertion of the thermocouples. Two thermocouples were inserted when studying the temperatures produced in cortex and in marrow simultaneously. In the majority of experiments in this series, measurement of temperature was limited to the cortex. The surgical procedures for placing the thermocouples in the femur of the dogs were as follows: After the dogs had fasted for twenty-four hours, anesthesia was induced by the intravenous injection of pentobarbital sodium (25 mg./kg. of body weight). A small incision on the medial aspect of the dog's thigh about 6 cm. above the knee was made, and the femur was exposed by blunt dissection. A hole slanting toward the hip joint was drilled through the cortex of the femur, extended through the marrow, and drilled halfway into the lateral cortex. A blunt needle thermocouple having the same outside diameter as the hand drill was placed in this hole. In ten femurs, a second hole was drilled vertically through the medial cortex proximal to the first hole. A second thermocouple was placed in the bone marrow through this hole. The position of the thermocouples was checked roentgenographically. In this manner, it was attempted to place one thermocouple in the bone marrow so that it would be in the same frontal and transverse planes as the tip of the thermocouple which had been placed in the bone cortex.

The question was raised concerning the influence which these operative procedures, particularly the drilling of holes in the cortex, would have on the histologic changes. In order to rule out this influencing factor, a second series of ten dogs was selected for further study. The femurs of these dogs were untouched surgically. To study the histologic changes produced by the drilled hole per se, a hole was drilled into the cortex of the right humerus using the same technic as that described for the femur. Following this procedure, the wound was closed in layers so that the operative technic was the same as that used on the femurs of the other sixteen dogs.

Only the femurs of all the dogs were exposed to ultrasonic energy. The sound head was applied to the lateral surface of the cleanly shaven thigh which had been coated with mineral oil (as a coupling medium). The sound head was clamped vertically above and lightly touching the skin over the area of the femur which contained the thermocouples. Precise positioning of the sound head and leg was accomplished by arranging the femur in the ultrasonic field so that the maximal acceleration of rise in temperature was obtained. In those twenty thighs which contained no thermocouple, the ultrasonic energy was applied between 6 and 9 cm. above the knee joint. The unexposed bones served as the control in these investigations on histologic changes owing to ultrasound.

Ultrasonic powers ranging from 5 to 20 watts and durations of exposure from 2 to 5 minutes were used in these studies. Femurs received from 1 to 25 ultrasonic irradiations during a particular experiment. The dogs were killed at intervals following ultrasonic irradiation varying from one-half hour to twenty-one weeks. Histologic sections were made from their femurs and humeri.

Results

Temperatures Produced in Femurs.— When the minimal dose of 5 watts of ultrasonic power for two minutes was used, the average rise in temperature was 6.32 C. in the marrow and 12.28 C. in the cortex. When the output was 10 watts and the duration of exposure was two minutes, temperature rises as high as 49.15 C. were observed in the cortex. Higher temperatures were produced when femurs were exposed to 15 and 20

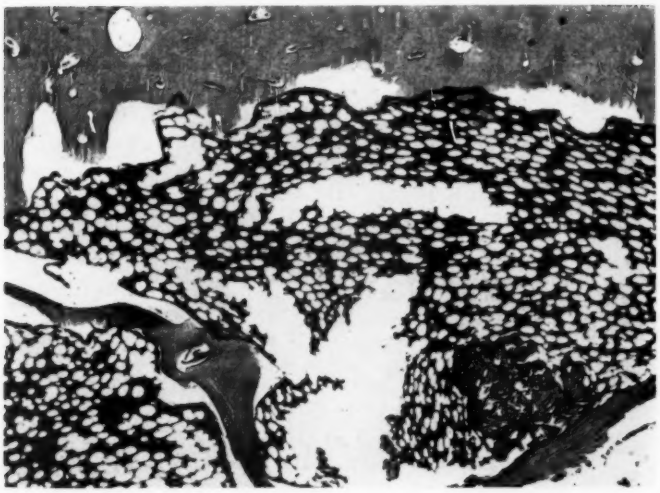

Fig. 1 — Normal bone marrow of femur of dog (hematoxylin and eosin stain; x35).

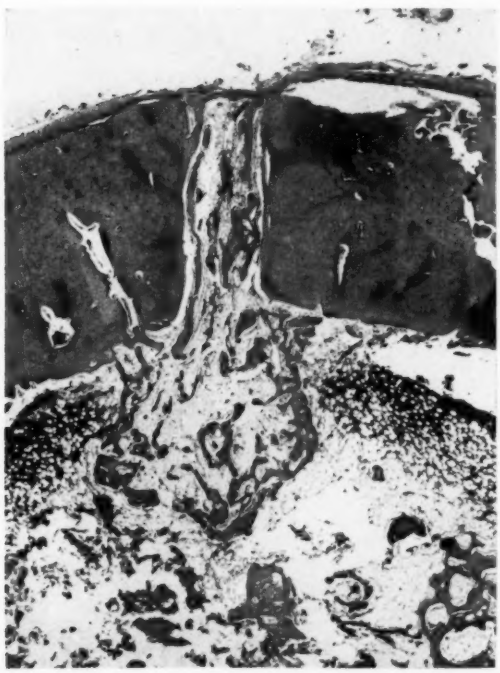

Fig. 2 — Hole in cortex. Osteogenesis apparently emerging from site of drill hole and extending into the marrow cavity of the femur following 20 exposures to varying intensities of ultrasound. Dog killed four weeks after experiment (hematoxylin and eosin stain; x15).

watts of ultrasonic power for three to five minutes.

Histologic Changes. Bone Cortex.—There appeared to be no histologic change in the cortices of the irradiated bones of either series of dogs.

Bone Marrow.—The marrow in the irradiated bones was much better preserved than that of the control bones. This raises the question as to whether or not ultrasound rendered the cortex more permeable to the formalin fixative.

The marrow of the control bone was fragmented in many cases, but was otherwise normal (fig. 1).

Histologic sections at the site of the drill hole were made in several of the femurs exposed to ultrasound. Osteogenesis appeared to emerge from the drill hole and to expand into the marrow

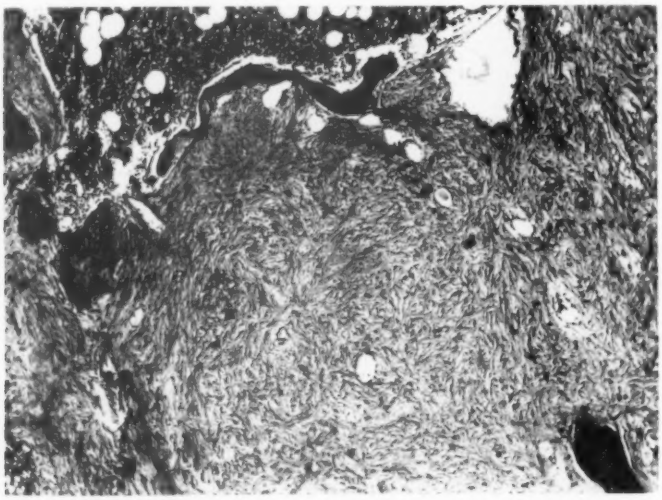

Fig. 3 — Fibrosis in marrow following 5 exposures to 15 watts of ultrasonic power for two minutes. Dog killed five weeks after experiment (hematoxylin and eosin stain, x60).

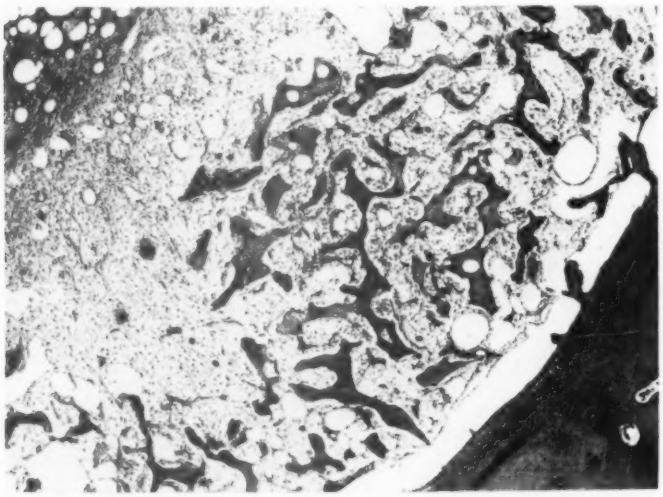

Fig. 4 — Osteogenesis in marrow of femur following 3 exposures to 20 watts of ultrasonic power for five minutes. Dog killed three weeks after experiment (hematoxylin and eosin stain; x35).

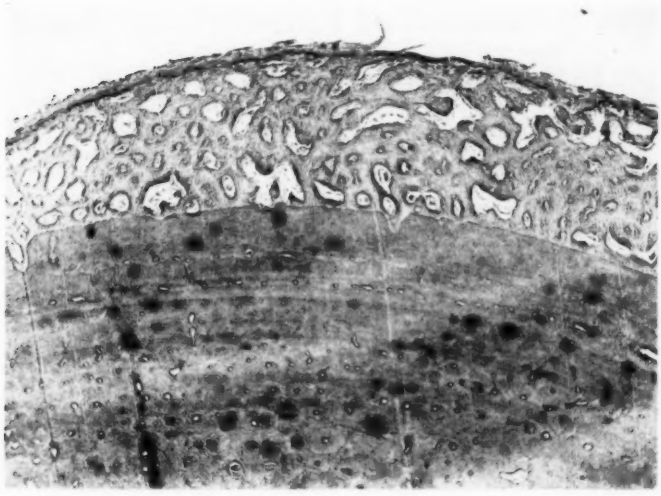

Fig. 5 — Subperiosteal new bone formation. Clear spaces represent large vascular channels accompanied by periosteal tissue. Dog was exposed twice to 15 watts of ultrasonic power for two minutes. Dog killed four weeks after experiment (hematoxylin and eosin stain; x26).

cavity (fig. 2).

Histologic sections at the site of the drill hole in those bones which were not exposed to ultrasound showed no osteogenesis.

In general, in cases in which the rise in temperature of the marrow was less than 7 C., hemorrhage was the most constant finding. In instances in which the temperature was higher, the most striking findings in the marrow were fibrosis and osteogenesis (fig. 3 and 4). Osteogenesis was observed in thirteen of fourteen thighs receiving the higher doses, namely, 15 to 20 watts for five minutes. Fat necrosis and giant cells were occasionally observed.

Periosteum.—In several instances, subperiosteal new bone formation was found (fig. 5).

Summary

When the femurs of adult dogs were exposed to ultrasound, no significant histologic changes were observed in the cortices. However, the marrow showed striking changes. Hemorrhage occurred in the marrow of those bones which were heated moderately, that is, temperature rises of less than 7 C. When the temperature rise exceeded 7 C., osteogenesis and fibrosis occurred. In several instances, subperiosteal new bone formation was found. Occasionally, fat necrosis and giant cells appeared.

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Strength Decrement of Elbow Flexor Muscles Following Exhaustive Exercise

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Plentiful information exists describing the effects of general body endurance activities, i.e., running, swimming, and the like, upon heart rate, blood pressure, and other cardiovascular phenomena, as well as the rate of recovery, or return to normal, following such exercise. However, no objective evidence is available relative to the effects of exhaustive muscular efforts upon strength and strength recovery rate. The study of these effects was the purpose of this research.

The elbow flexor muscles were selected as the muscle group to be studied because of the availability of objective technics for measuring both their strength and endurance. It was thus possible largely to isolate the muscles to be studied and to confine the laboratory measurements to the muscles directly under stress.

Experimental Procedures

The experimental procedures followed in this study were:

1. Once each week for six weeks, the subjects exercised their elbow flexor muscles on the Kelso-Hellebrandt[1] ergograph until an exhaustion state was reached, i.e., until the muscles were no longer able to move the ergograph load the slight distance necessary to register on the cumulative distance meter. Insofar as possible, the subjects worked on the ergograph on the same day and hour each week. The left arm was utilized throughout the experiment.

2. Ergography was performed in accordance with the technics described by Clarke[2]. The ergograph load was three-eighths proportion of each subject's elbow flexion strength; the length of the lever arm was eight inches for all subjects; the cadence was one second each for flexion and for extension; all movements were made in a uniformly smooth manner (fig. 1).

ELBOW FLEXION - WITHOUT BRACES

Fig. 1

3. Cable-tension strength tests[3] of the elbow flexor muscles were given before, 30 seconds after, and at stated intervals for some time following exercise. Graphs were prepared portraying the changes in mean elbow flexion strength.

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This study of strength recovery following exhaustive exercise was a preliminary phase of a larger investigation of the effect of carrying loads on muscular strength being conducted at Springfield (Mass.) College under subsidy from the Climatic Research Laboratory, Quartermaster Corps, Department of the Army.

4. Comparisons of the mean elbow flexion strength of the subjects following exercise were made with the pre-exercise mean. The significance of differences between means was tested by the null hypothesis. The number of cases for the various exercise sessions varied somewhat. With the exception of the last week of the experiment, the number was between 23 and 28. Using 26 as N, the modal number, *t*-ratios of 1.71 and 2.49, denote approximate significance at the 0.05 and 0.01 levels of confidence respectively[4].

5. The subjects selected were male students at Springfield (Mass.) College. Inasmuch as most of these men were physical education majors, they were thought to be physically superior to college students in general. This assumption proved valid upon testing the subjects for such factors as weight, height, Strength Index[5], Physical Fitness Index[5], and somatotype[6]. Quite possibly, the nature of the subjects may be significant in results obtained from an experiment requiring arduous physical efforts.

6. The testers were carefully trained in strength testing and ergographic procedures. Before being permitted to collect any test data for research purposes, they were required to demonstrate competence in the administration of the tests by achieving objectivity coefficients as high in each instance as had been obtained formerly.

Results of the Experiment

This study into strength decrements caused by fatiguing muscular exertion and the strength recovery of the elbow flexor muscles thus exercised may be divided into the following three phases: (1) effect on untrained subjects at rest between post-exercise strength tests; (2) effect on trained subjects under varying conditions, and (3) effect on trained subjects followed for two hours after exercise.

Untrained Subjects at Rest: The first two weeks of the experiment constituted phase one. Prior to this phase, the subjects received instructions in taking ergographic tests and only enough practice to learn the technics. Since only a minimum of training and muscle conditioning had taken place, the subjects were considered as untrained. Strength tests were administered at the following times after the exhaustive ergographic exercise: 30 seconds; 2 minutes, 30 seconds; 5 minutes, 30 seconds; 8 minutes; 10 minutes, 30 seconds; and every five minutes thereafter, until 45 minutes, 30 seconds, had elapsed. The subjects were at rest, supine, lying with minimum movement of the exercised arm, between strength tests.

The results of this testing appear in table 1 and are portrayed in graph form in figure 2. The characteristics of these strength decrement curves are:

1. A very pronounced drop in strength was found 30 seconds after exercise. The mean decrement was 30 pounds, or 31 per cent, for the first week; and 33 pounds, or 33 per cent, for the second week. The *t*-ratios for the differences between the means for the pre-exercise and 30 second strength tests were 12.50

Table 1. Mean Strength in Pounds Pull of Elbow Flexor Muscles Before and After Exhaustive Ergographic Exercises: Untrained Subjects at Rest (Data: 1952-53; 26 to 28 Subjects)

Test	First Week		Second Week	
Period	M (lbs)	% Loss	M (lbs)	% Loss
Pre-Exercise	98		100	
Post-Exercise				
30 sec.	68	31	67	33
2 min. 30 sec.	77	21	70	30
5 min. 30 sec.	77	21	71	29
8 min.	75	23	73	27
10 min. 30 sec.	76	22	73	27
15 min. 30 sec.	79	19	75	25
20 min. 30 sec.	80	18	74	26
25 min. 30 sec.	79	19	76	24
30 min. 30 sec.	80	18	76	24
35 min. 30 sec.	80	18	76	24
40 min. 30 sec.	79	19	75	25
45 min. 30 sec.	77	21	72	28

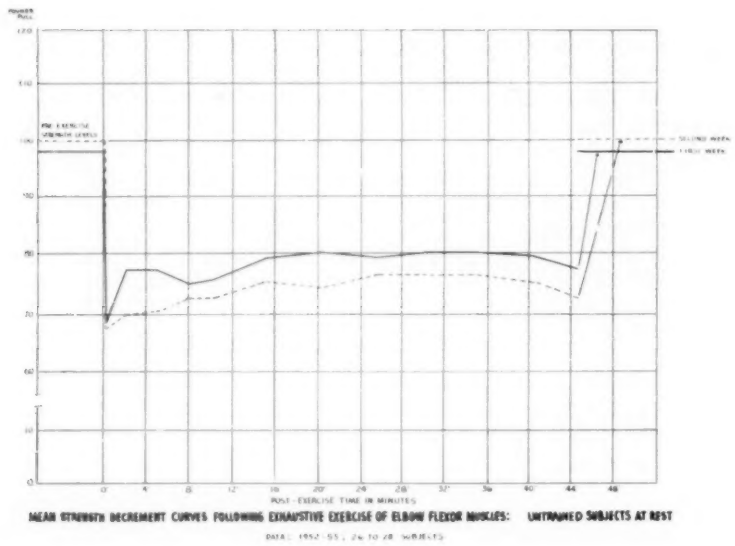
POST-EXERCISE TIME IN MINUTES
MEAN STRENGTH DECREMENT CURVES FOLLOWING EXHAUSTIVE EXERCISE OF ELBOW FLEXOR MUSCLES: UNTRAINED SUBJECTS AT REST

Fig. 2

and 10.60 for the first and second weeks respectively. When combined with similar data from another study conducted concurrently, which increased the number of subjects to 51, the *t*-ratios were 19.36 and 18.50. Thus, there can be no question of the statistical significance of these results.

2. An initial rise in strength was noted within the next two minutes after exercise. For the first week, this rise was nine pounds, or 30 per cent of the decrement; for the second week, the rise was only three pounds, or 9 per cent of the loss. The differences between the pre-exercise and 2 minutes, 30 seconds strength tests were statistically significant well beyond the 0.01 level of confidence; the *t*-ratios for the first and second weeks were 9.6 and 17.95 respectively.

3. The strength recovery curve for the second week, where the initial gain was small, continued to rise until eight minutes had elapsed. Both curves, however, leveled off and showed no appreciable gain throughout the remaining time. The strength decrement means at the end of 40 minutes, 30 seconds after exercise were still 19 per cent and 25 per cent below the pre-strength levels. These differences are also statistically significant; the *t*-ratios were 3.78 and 5.14 for the first and second weeks respectively. The slight declines in strength during the last five minutes were due to the loss of a number of subjects at the final testing time.

4. Only four subjects, or 14 per cent, had returned to their pre-exercise strength level by the end of 45 minutes.

Trained Subjects Under Varying Conditions: For the second phase of the study, a different group of subjects was used. These subjects had not only been instructed in ergographic testing technics, as was true for those in phase one, but had participated in four exhaustive exercise sessions on the ergograph prior to their inclusion in this phase of the research. As discovered in other studies[7], considerable strength and endurance conditioning of the elbow flexor muscles takes place as a result of this amount of ergographic exercise. These subjects, therefore, were considered trained in contrast with those in the first phase, although it is recognized that conditioning would continue to occur as the experiment progressed.

Phase two of the study was conducted for three weeks. The conditions of the experiment varied each week. During

the first week, subjects moved about the laboratory at will during the time between the strength tests, thus increasing general body circulation. In the second week, subjects did the same as in the first week, but added massage and active movement (not strenuous) of the exercised arm; and in the third week, subjects were at rest, supine, lying with minimum movements of the exercised arm between strength tests, as in phase one.

The results of phase two are shown in table 2 and appear graphically in figure 3. Observations made from these strength decrement curves of the elbow flexor muscles are:

1. The curves follow the same general pattern as found in the previous phase of the study. The initial drop was pronounced, and was approximately the same as before (29 - 32 per cent). This drop was followed by an initial sharp rise and a leveling off to the end of the time period. The major difference between the two phases is that the trained subjects returned consistently to a higher level at the end of the test period; that is, 19 and 25 per cent below pre-exercise levels for the untrained subjects and 5 to 10 per cent for the trained subjects.

2. The usual statistical significance between the strength test means was found for the three weeks of this phase.

Table 2: Mean Strength in Pounds Pull of Elbow Flexor Muscles Before and After Exhaustive Ergographic Exercise: Trained Subject Under Varying Conditions (Data: 1952-53; 23 to 26 Subjects)

Test	Third Week[1]		Fourth Week[2]		Fifth Week[3]	
Period	M (lbs)	% Loss	M (lbs)	% Loss	M (lbs)	% Loss
Pre-Exercise	106		114		116	
Post-Exercise						
30 sec.	74	30	78	32	82	29
2 min. 30 sec.	87	18	92	19	94	19
7 min. 30 sec.	93	13	101	11	101	13
12 min. 30 sec.	97	8	102	11	103	11
17 min. 30 sec.	97	8	102	11	103	11
22 min. 30 sec.	98	8	104	9	103	11
27 min. 30 sec.	98	8	105	8	105	9
32 min. 30 sec.	99	7	106	7	105	9
37 min. 30 sec.	99	7	108	6	105	9
42 min. 30 sec.	101	5	109	4	104	10

[1] Subjects moving about between strength tests.
[2] Subjects moving about and massaging exercised arm between strength tests.
[3] Subjects supine lying at rest between strength tests.

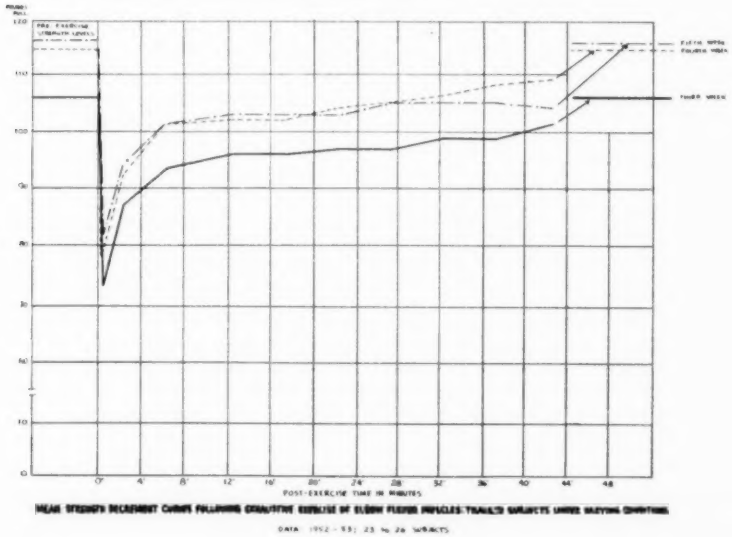

Fig. 3

The *t*-ratios were: pre-exercise to 30 seconds after exercise, 12.85 to 17.12 (14.15 to 26.29 for combined groups of 50 subjects); pre-exercise to 2 minutes, 30 seconds after exercise, 6.26 to 10.75; and pre-exercise to 42 minutes, 30 seconds after exercise, 2.84 to 5.76. Although the differences between the pre-exercise and last means were quite small, still they are statistically significant. The final means were preceded by consistently similar test results. Slight gains only in elbow flexor strength were found for all three curves from 12 minutes, 30 seconds after exercise to the end.

3. In this phase, a larger number of subjects reached their pre-exercise elbow flexor strength than was true before. The numbers were: fourteen for the third week; ten for the fourth week; and six for the fifth week. In general, then, more subjects regained their normal strength when permitted to move about and massage their exercised arms than when rest was required between strength tests.

4. The differences in strength recovery for trained subjects when moving about between strength tests and when moving about and massaging the exercised arm were minor in nature and of no consequence. When the subjects were supine and lying at rest between strength tests, however, the mean decrement was greater at the end of the testing time (10 per cent as contrasted with 4-5 per cent). The difference of 6 per cent is statistically significant at the 0.05 level of confidence. The *t*-ratio is 1.71.

Trained Subjects Followed for Two Hours: During the third phase of the experiment, which lasted for one week only, strength tests were given to the subjects for approximately two hours after exhaustive exercise of the elbow flexor muscles, at the following times: 30 seconds; 2 minutes, 30 seconds, and each 10 minutes thereafter until 122 minutes, 30 seconds had elapsed. The subjects were permitted to move about at will and massage their exercised arms between strength tests as was done during the fourth week (second week, second phase) of the experiment. Eighteen subjects participated in this phase. Significant *t*'s for the difference between means with this number of cases are 1.75 and 2.58 at the 0.05 and 0.01 levels of confidence respectively.

The results of phase three of the study are presented in table 3 and appear in graph form in figure 4. Median scores are used in this instance in order to eliminate the effects of an extreme pre-exercise strength score which resulted in a spuriously high mean. Inferences from these data are as follows:

1. Once more, the strength decrement curve has the same general shape as those previously described. The initial drop was 33 per cent, followed by recoveries to 20 per cent and 10 per cent below pre-exercise strength means at 2 minutes, 30 seconds and 12 minutes, 30 seconds; after the latter point, the gains were small and slow with a virtual plateau until 72 minutes, 30 seconds had elapsed; thereafter, an additional gain of four decrement percentage points occurred, which was continued approximately at this level to the end of the testing time.

2. With reference to the previous phases of the study, a question might logically be raised concerning the fatiguing effect of taking repeated strength tests with short rest periods between tests. Apparently this is not a significant factor, since a similar mean decrement curve was obtained in phase three, when the strength tests were ten minutes apart. Furthermore, only four subjects had returned to normal at the close of the testing time.

Summary

In interpreting the results of this study of strength loss following fatiguing exertion, the process of exercising the muscles should be kept clearly in mind. This process was: (a) The elbow flexor muscles of the left arm were exercised on the Kelso-Hellebrandt ergograph; (b) the ergrographic weight loads were equal to three-eighths proportion of each subject's elbow flexor strength; (c) the cadence was one second for contraction alternated with one second for relaxation,

and (d) exercise continued to exhaustion, i.e., until the subject was no longer able to lift the load the slight distance necessary to record on the cumulative distance meter of the ergograph. Each exercise bout consisted of approximately sixty muscular contractions and lasted about two minutes.

A characteristic strength decrement curve resulted, which reflected the immediate effect on elbow flexion strength of exhaustive efforts and indicated the strength recovery rate for three-quarters to two hours after cessation of exercise. *The general form of this curve was consistently repeated each week for the six weeks of the experiment.* A description of this curve is (a) a pronounced drop in strength (29 to 33 per cent) at 30 seconds after exercise; (b) an initial rise in strength during the next two minutes, continuing at a decelerated rate for an additional ten minutes, and (c) leveling off with slight, if any, increase for the balance of the testing time.

The correlation between pre-exercise and 30 seconds after exercise strength scores was 0.83, which is high, falling

**Table 3: Median Strength in Pounds Pull of Elbow Flexor Muscles Before and After Exhaustive Ergographic Exercise: Trained Subjects Followed for Two Hours*
(Data: 1952-53; 18 Subjects)**

Test Period	Sixth Week		
	Mdn (lbs)	% Loss	No. Recovered
Pre-Exercise	110		
Post-Exercise			
30 sec.	74	33	
2 min. 30 sec.	88	20	
12 min. 30 sec.	99	10	
22 min. 30 sec.	99	10	
32 min. 30 sec.	99	10	1
42 min. 30 sec.	101	8	1
52 min. 30 sec.	101	8	
62 min. 30 sec.	100	9	
72 min. 30 sec.	102	7	
82 min. 30 sec.	107	3	1
92 min. 30 sec.	107	3	1
102 min. 30 sec.	107	3	
112 min. 30 sec.	106	4	
122 min. 30 sec.	106	4	

*Medians are used in this table in order to eliminate the effect of pre-exercise strength score which resulted in a spuriously high mean.

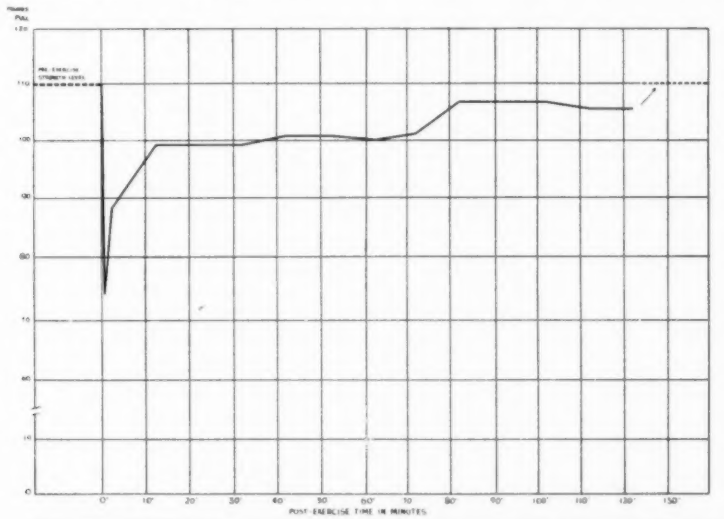
POST-EXERCISE TIME IN MINUTES
MEDIAN STRENGTH DECREMENT CURVE AFTER EXHAUSTIVE EXERCISE OF ELBOW FLEXOR MUSCLES: TRAINED SUBJECTS FOLLOWED FOR TWO HOURS
DATA: 1952 - 53 ; 18 SUBJECTS

Fig. 4

within the range of recorded objectivity coefficients. Thus, this relationship indicates considerable consistency from subject to subject in initial strength decrements.

No appreciable difference existed in the percentage strength decrement 30 seconds after exercise of untrained and trained subjects. However, the trained subjects returned consistently to a higher point at the end of 42 minutes, 30 seconds: 21 to 24 per cent below pre-exercise levels for the untrained subjects; and four to ten per cent for the trained subjects.

The percentages of strength decrements were approximately the same for trained subjects when moving about between strength tests and when moving about and massaging the exercised arm. When the subjects were supine lying at rest between strength tests, however, the mean decrement was greater at the end of the testing time (10 per cent as contrasted with 4-5 per cent). Thus, mild general circulation resulting from body movement increased the strength recovery rate following exhaustive exercise.

Recovery from loss of strength resulting from exhaustive efforts was not complete at two hours after exercise which was the longest period the subjects were tested. It is still unknown when the strength scores of the subjects reach their pre-exercise performances.

The strength conditioning effect of the elbow flexor muscles, which resulted from five exhaustive exercise sessions, is indicated by the pre-exercise means. Beginning with a mean of 98 pounds, the mean was 116 pounds at the end of the experiment, a gain of 18 pounds, or 18 per cent.

Conclusion

This study has justified the hypothesis that an immediate effect of fatiguing muscles is to reduce their ability to apply muscular strength. Under the conditions of this experiment, the approximate amounts below pre-strength levels at different time periods following exercise were as follows: 30 seconds, 29 to 33 per cent; 2 minutes, 30 seconds, 18 to 20 per cent; 12 minutes, 30 seconds, 8 to 11 per cent; and both 42 minutes, 30 seconds and 122 minutes, 30 seconds, 4 to 5 per cent. With untrained subjects, the final decrements are greater.

Acknowledgement — The authors are grateful to Gavin Carter, David H. Clarke, Karl K. Klein, Marakala Mohana, Eng-Hauw Tan and James Torpey for their assistance in this study.

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Discussion

Dr. R. W. Boyle (Milwaukee): The evaluation of strength-endurance testing has been debated and discussed, for many years, by the anatomist, physiologist, and physical educator. This type of testing along with circulatory and respiratory tests has been the basis of many so-called physical efficiency tests. The value of these tests has definite clinical implications which might apply to the restoration of cases sent to the Physical Medicine and Rehabilitation Service.

For years, some physiatrists have interested themselves, primarily, in the problems of work capacity and work tolerance. The practical aspects of such research as Dr. Clarke's may well be a stepping stone in the right direction. The need is great for simple tests that

can be given to debilitated patients. It is only right that such tests first be made on healthy subjects and then to proceed with the modifications necessary to test weakened muscles and their endurance on such cases as those suffering from anterior poliomyelitis, multiple sclerosis, paraplegia, tuberculosis, rheumatic heart disease, and a host of others.

The use of the De Lorme resistive exercise technic is being modified and seems to conform to the curves which Dr. Clarke has shown. There is a certain amount of disparity between the theory that overwork in some degree produces stronger muscles and more muscle hypertrophy and the theory that a fatigued or atrophied muscle may be injured by overwork. Certainly Dr. Clarke's healthy subjects can voluntarily inhibit a dangerous show of strength or power as indicated by his graphs.

A physiologist would probably be interested in the site of this fatigue. Is it in the muscle, in the neuromuscular junction, in the lower motor neuron synapse, or in the upper motor neuron synapse? He might also be interested in the chemistry involved. Is it in the enzymatic reaction of the acetylcholine-cholinesterase cycle, in the acto-myosin configuration involved with its complex enzymatic cycle, or perhaps in a combination of both? Certainly Dr. Clarke's figures indicate that circulation plays a part in the total picture.

The work done in Dr. Clarke's laboratory and that done by Doctors Wakim, Fischer, and others, indicates a need to continue such projects with some definite correlation between these various phases before the problem will be better understood and before general clinical application can be made with sound understanding.

Metabolic Requirements of Occupational Therapy Procedures

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Frederic J. Kottke, M.D.
and
Jean Magney, B.S., O.T.R.
Minneapolis

In recent years occupational therapy has become more and more an integral part of the practice of medicine and especially so in the treatment of those patients who have a disability which permits them only partial activity. Since this is the case, it is desired to have the different therapeutic activities graded so that one may prescribe an activity which would be within the limits of the work tolerance of the patient and thereby avoid overwork and fatigue. This is of utmost importance when one prescribes activities for an individual with a diseased heart which can no longer cope with the demands put upon it and the functional cardiac reserve of which is limited. The knowledge of graded activities would also be useful in prescribing activities for patients suffering from diseases such as rheumatic fever with decompensation or tuberculosis so that, as the disease comes under control and the patient improves, the therapeutic activities can be prescribed in sequence to improve the patient's strength and endurance. Gordon has measured the metabolic rates in various activities to determine the energy costs of physical activities in relation to pulmonary tuberculosis[1].

This study was designed to measure

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the energy consumption and cardiac output required by various standard occupational therapy procedures.

Methods

Metabolic rates were measured as the basis for calculating energy expenditure. The metabolic rates were measured by determining the oxygen consumption in the usual manner utilizing the McKesson Waterless Metabolor connected by five feet of tubing, one inch in internal diameter, to a standard flanged rubber mouth piece[2]. The subjects were in a near basal state, having had no food for at least four hours prior to the test and having rested for thirty minutes immediately before the initial test. Each test was for a six minute period after the subject had reached a steady state in the activity being done.

The cardiac outputs were measured indirectly, utilizing the Fick principle, by Grollman's acetylene gas method[3]. The Fick principle states that:

$$\text{Cardiac output} = \frac{\text{gas absorbtion}}{\text{gas concentration (arterial)} - \text{gas concentration (venous)}}$$

The cardiac output in liters per minute equals the oxygen consumption expressed in cubic centimeters per minute divided by the arteriovenous difference as found by the equation:

$$\text{Cardiac output} = \frac{\text{(oxygen consumption)} \times (C_2H_2)\ \text{diff.}}{(O_2)\ \text{diff.} \quad (C_2H_2)\ \text{av.} \quad (B\text{-}48.1) \quad (K)}$$

This method consists of rebreathing a mixture of acetylene in air from a rubber bag until a homogeneous mixture is obtained in the lung bag system. The rebreathing bag contains 450 cc. acetylene, 150 cc. oxygen and 1400 cc. room air thus making a total of 2000 cc. to be rebreathed. A special three-way aluminum stopcock is used. This stopcock has three small openings to which the evacuated gas sampling bottles may be attached. The end with the three small openings is inserted into the collar of the rubber rebreathing bag. The other end has the rubber flanged mouthpiece. The third opening is to the outside air. The subject has a nose clip in place to prevent any breathing through the nose. The subject exhales completely through the opening to the room air. At the end of expiration, the stopcock is turned so that when the subject inhales, he will be breathing the acetylene—oxygen mixture. The subject takes at least four complete respirations, emptying the bag with each inspiration in a nine second period. At nine seconds the first gas sample is taken from the homogenous mixture in the rebreathing bag. The subject then repeats this with at least four more respirations and after the next nine second period another gas sample is taken. The final collection must be taken before any acetylene returns to the right heart; this would be at about twenty-two seconds after the test is begun. The gas samples are then analyzed with the Haldane apparatus.

The entire study to date has included thirty-seven different subjects, all of whom were associated with the Occupational Therapy Department of the University of Minnesota. Most of the subjects were students in occupational therapy. The others were either practicing therapists or members of the teaching staff. All of the subjects were familiar with the activities tested. Their ages ranged from 19 to 43 years and all were in good health.

Four activities have been studied so far. They are chip carving, table weaving, leather carving and hand sawing. The initial metabolism was measured in the supine position. The second metabolism was measured with the subject seated or standing in the position in which the activity would be done. The final metabolism was measured while the subject was doing the activity. A definite effort was made to maintain all the circumstances as constant as possible except for the activity being done. The difference in oxygen consumption would then be the amount required to carry out the activity.

In chip carving, the initial metabolism was taken while the subject was in the position of work; that is the subject was seated at a work table, with both elbows

on the table and the feet flat on the floor. The second metabolism was taken with the subject at work chipping out the wood block. Bass wood blocks were used. These blocks measured 3"x4"x¼" and were marked off in triangles. Bard Parker surgical knives were used for the chipping. Seventeen subjects were studied, with a total of fifty-three tests completed.

In table weaving the initial metabolism was again taken with the subject in the position of work. The subject was seated on a high stool before a small table upon which the Structo Table loom was placed. The forearms rested on the breast beam of the loom. The loom was strung with cotton carpet warp (218 threads) and the same material was used for filler. An eighteen inch shuttle was used. The subject was instructed to use both hands on the beater and to beat three times after each pick. The speed of work was controlled as closely as possible. Seventeen subjects were studied, with a total of forty-seven tests completed.

With the hand sawing activity, sixteen control tests were run with the subject reclining, and repeated in the standing position as though ready to work. The final test was taken with the subject at work. An additional thirty-one tests were done with the subjects in the position of work and then at work. A three-quarter inch oak board and a ten point crosscut hand saw were used. The timing of each stroke of the saw was accomplished by means of a metronome which was set at sixty strokes per minute. One stroke was a complete push and pull.

There were thirteen subjects with a total of thirty-four tests in the leather carving activity. In all of the tests a metabolism determination was taken with the patient in the supine position, in the position of work, and finally at work. The position of work was similar to that in chip carving with the subject seated at a table, elbows resting on the table and the feet flat on the floor. The leather was a 3 x 4 inch piece of six ounce cowhide. A standard pattern was used throughout the test. The same swivel knife was used by all the subjects. A sharp edge was maintained on the knife at all times. As a rule the pattern could be carved completely in the six minutes allowed for the test.

Results

The subjects in the supine position at rest required from 30 to 43 Cal./M²/hr. with a mean of 36 Cal./M²/hr. (table 1).

The metabolic requirement in the sitting position ranged from 31 to 48 Cal./M²/hr. with a mean of 40 Cal./M²/hr. or a mean per cent increase of 12 per cent over the requirement when supine. Standing showed a mean

Activity	Number of Subjects	Number of Tests	Mean Cal/sq.M/hr.	Standard Deviation	S.E.M.	% increase over Supine
Supine	13	34	36.6	4.2	.73	
Sitting	17	53	42.0	4.9	.85	11%
Chip Carving	17	53	58.5	6.1	.83	59%
Leather Carving	13	34	61.4	8.3	1.4	67%
Table Weaving	17	47	61.6	7.3	1.06	68%
Hand Sawing	16	47	119.0	26.0	3.8	225%

Table 1 — The metabolic requirement of various activities carried on in Occupational Therapy compared to lying or sitting at rest. Metabolism in calories per square meter per hour was calculated from the oxygen consumption. The standard deviation of each activity and standard error of the mean for each activity is shown.

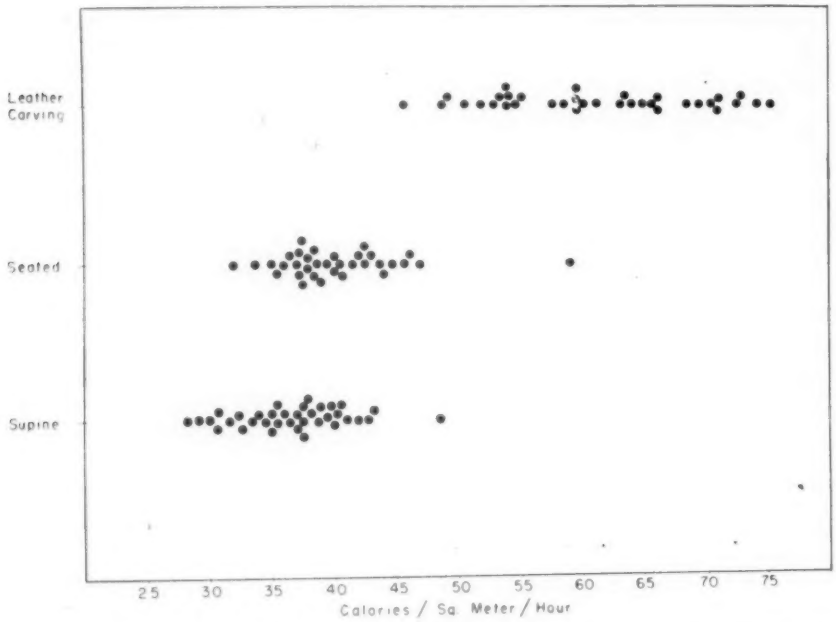

Fig. 1 — Scattergram showing the metabolic demand in calories per square meter per hour of the reclining and sitting positions compared with leather carving for individual tests carried out on thirteen subjects.

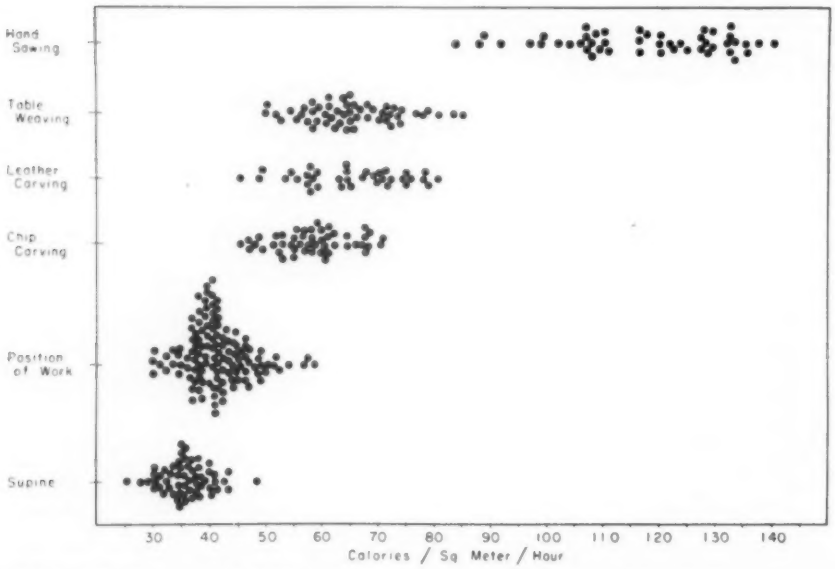

Fig. 2 — Scattergram of individual tests showing the metabolic demand in calories per square meter per hour of chip carving, leather carving, table weaving, and hand sawing compared with the reclining position and the position of work.

per cent increase of 13 per cent above the requirements when supine (31.7 - 53.2 Cal./M²/hr.).

The chip carving activity required from 45 - 72 Cal./M²/hr. with a mean of 59 Cal./M²/hr. or a mean per cent increase of 59 per cent.

In leather carving the range was from 48 Cal./M²/hr. to 74 Cal./M²/hr. with a mean of 61 or a mean per cent increase of 67 per cent (fig. 1).

Table weaving required from 50 Cal./M²/hr. to 74 Cal./M²/hr. with a mean expenditure of 62 Cal./M²/hr. This was a mean per cent increase of 68 per cent above the requirements when supine.

Hand sawing ranged from 92 Cal./M²/hr. to 151 or a mean expenditure of 119 Cal./M²/hr. This was a mean per cent increase of 225 per cent above the basal metabolism.

Discussion

We have attempted to grade four occupational therapeutic procedures namely chip carving, leather carving, table weaving, and hand sawing in terms of the energy requirements necessary to carry out these activities (fig. 2). These activities were selected originally because it was estimated that their energy requirement would vary throughout the range from light to heavy activity. The study thus far indicates that it requires about a 12 per cent increase above the basal requirements to maintain the sitting position and 13 per cent increase to maintain a relaxed standing position. Chip carving increased the demand by 59 per cent, leather carving by 67 per cent, table weaving by 68 per cent and hand sawing by 225 per cent (fig. 3). It may be seen that the three activities carried on while sitting show little difference in energy requirements.

The Grollman acetylene method of determining cardiac outputs has long been proved and accepted. It has the advantage that it can be used in many positions with many types of light or moderate work. In our study, to date, difficulties have arisen which prevented us from obtaining satisfactorily reproducible results. One such difficulty has been the inability of the body to rid itself of acetylene as rapidly as has been reported in the literature. Therefore, recently procedures have been revised to allow a longer time for gas equilibrium between tests. One general statement can be made from the data collected so far. The increase in the cardiac output appears to parallel the increase in oxy-

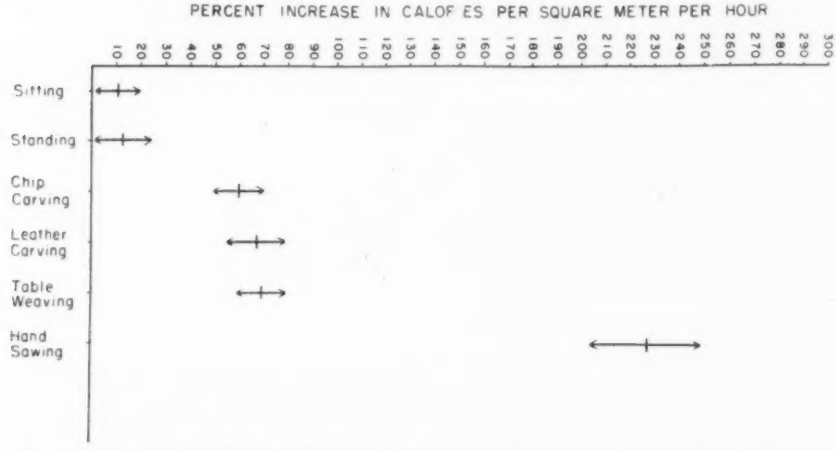

Fig. 3 — The increase in per cent of metabolic activity over basal with variation of posture or occupational therapy activities is shown. The mean increase of metabolic demand for each activity is indicated by the vertical bar and the range of increases obtained in all tests of each activity by the length of the arrows.

gen consumption for the different activities studied.

Plans have been made to continue this study with other activities and include the cardiac output results when we have improved our technic.

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Changes Occurring in Patellar Reflex and Electromyographic Voltages in Paretic Quadriceps

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The relation of the patellar reflex, muscle grade and electromyographic voltages may be of interest and assistance to the clinician in the evaluation of quadriceps weakness in cases of poliomyelitis. Several investigators[1-3] have reported the electromyographic voltages found in paretic muscles resulting from acute anterior poliomyelitis. Their reports seem to indicate a trend of higher voltages with increasing muscle strength. The present investigation was conducted to reveal the changes occurring in the patellar reflex and electromyographic voltages in the varying grades of quadriceps weakness.

Apparatus

The electromyograph used for this investigation was the type frequently employed as a clinical diagnostic aid. The instrument consisted of a four-stage amplifier, a cathode ray oscilloscope, loud speaker, and a synchronized camera. The machine was placed in a shielded room. Figure 1 shows the active electrode (monel) with a concave surface 3 cm. in diameter and 0.6 cm. deep. Small electroencephalographic needles were used as reference and ground electrodes.

A posterior splint (fig. 2) was used to support the knee so that a maximal reflex response was elicited. The optimal position was found to vary from 120 to 140 degrees of knee extension. A Lombard reflex hammer with a trigger release was so modified that, at the impact with the patellar tendon, a cocked spring returned the hammer to the original position. The "free fall" of the hammer produced a measured force of impact comparable to that produced by the

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clinician in eliciting the patellar reflex. A quadriceps boot was used, when needed, for maximal resistance.

Procedure

Subjects for this study were patients with clinical and laboratory evidence of poliomyelitis. Twenty males and forty-two females, between the ages of twelve and forty-seven years, were examined. In conducting this study, either or both thighs of the patient were used. A control group of normal subjects consisted

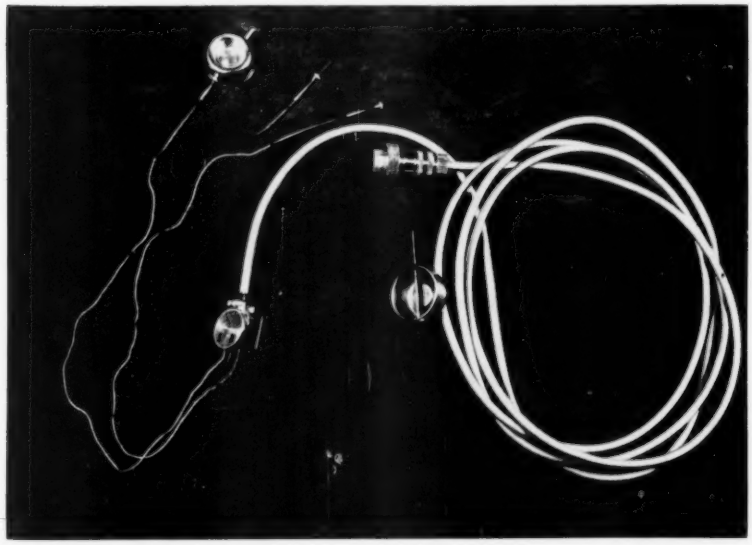

Fig. 1 — Electromyographic cable with monel metal active surface electrode and subcutaneous reference and ground needle electrodes.

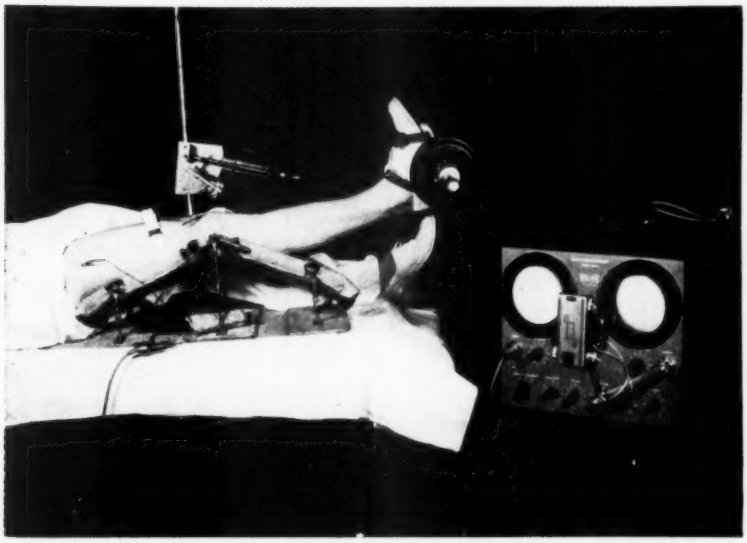

Fig. 2 — The application of electrodes, positioning of the subject's extremity with maximally loaded quadriceps, device for eliciting the patellar reflex and electromyograph for recording action potentials.

of five males and seven females. Their ages were from eighteen to fifty-six years and only the right thighs were used.

In the poliomyelitic group, experimental procedures were performed on patients in which from four months to two and one-half years had elapsed since the onset of their acute illness. There was no shortening in the hamstring muscles sufficient to interfere with quadriceps function in the testing position.

Each experiment consisted of the following steps: careful grading of the quadriceps, using a modification of the Lovett system of muscle testing, determination of the patellar reflex; measuring the maximal quadriceps load; and recording of electromyographic voltages at three determined points over the quadriceps mass. The reference electrode was placed 1.5 cm. proximal to the upper border of the patella. The ground electrode was inserted in the lateral aspect of the thigh. The active electrode was placed successively at 9, 16.5, and 25.5 cm. above the patella. The active electrode and skin were lubricated with Cambridge electrode jelly[3]. Patellar reflexes were graded with the following criteria: zero—no response; one—visible or palpable tendon motion and muscle contraction without extension of the knee; two—good muscle contraction and slight leg motion, considered normal; three—overactivity with increased leg motion, and four—overactivity with clonus.

In an attempt to obtain maximal quadriceps contraction in the testing position, specific instructions in knee extension were given to the subjects. When the leg was fully loaded and in maximal extension, photographs were taken of the single sweep voltages appearing on the oscilloscope. Measurements of the maximal peak-to-peak voltage were made from these photographs. Two samplings were made at each of the three designated points over the quadriceps muscle.

Results

Figure 3 is a summary of the distribution of patellar reflex changes and the electromyographic measurements of

MUSCLE GRADE	NO. OF SUBJ.	AV. DUR. MOS.	PATELLAR REFLEX GRADE 0	1	2	AV. WT. LIFTED (LBS.)	ELECTROMYOGRAPHIC VOLTAGES Position 1*	Position 2*	Position 3*
Normal	12	0	0	0	12	24.4	1833	2085	2188
Good +	19	10	0	2	17	24.8	1844	2303	2736
Good	8	9	2	4	2	15.0	1531	2372	2638
Good -	8	12	1	6	1	11.7	1382	1894	1815
Fair +	4	7**	2	2	0	1.75	1557	1131	1232
Fair	2	5	0	2	0	1.4	925	1344	750
Fair -	4	7	1	3	0	0.3	863	1299	966
Poor +	9	9	7	2	0	0.0	455	358	420
Poor	1	9	1	0	0	0.0	73	115	148
Poor -	2	6	2	0	0	0.0	111	139	121
Trace	5	12	5	0	0	0.0	34	55	93

Fig. 3 — Patellar reflex changes and the averages of electromyographic voltages of maximally loaded normal and paretic quadriceps muscles. *Positions 1, 2 and 3 refer to the location of the active electrode in the distal, middle and proximal segments of the quadriceps muscle respectively. **One case, 8 years post onset, is not included in this average.

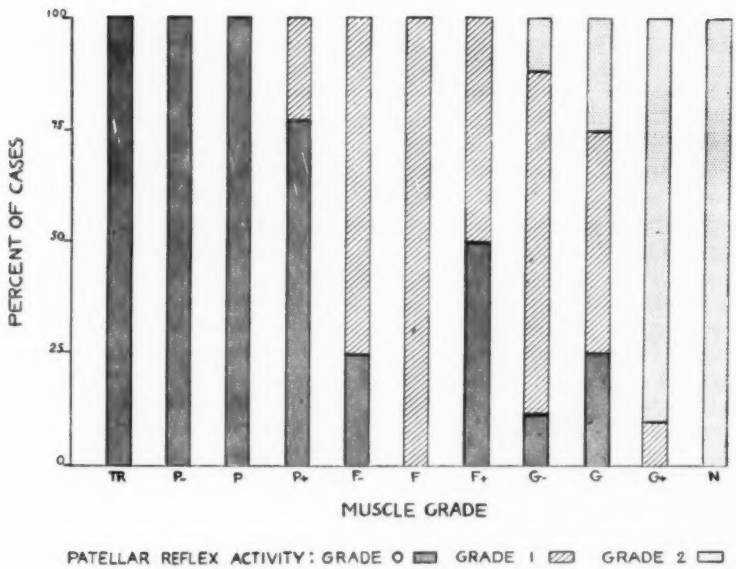

Fig. 4 — Patellar reflex activity in normal and paretic muscles.

maximally loaded normal and paretic quadriceps muscles. The table shows that the average maximal quadriceps load was in direct proportion to the strength of the muscle.

The data contained in figure 4 show

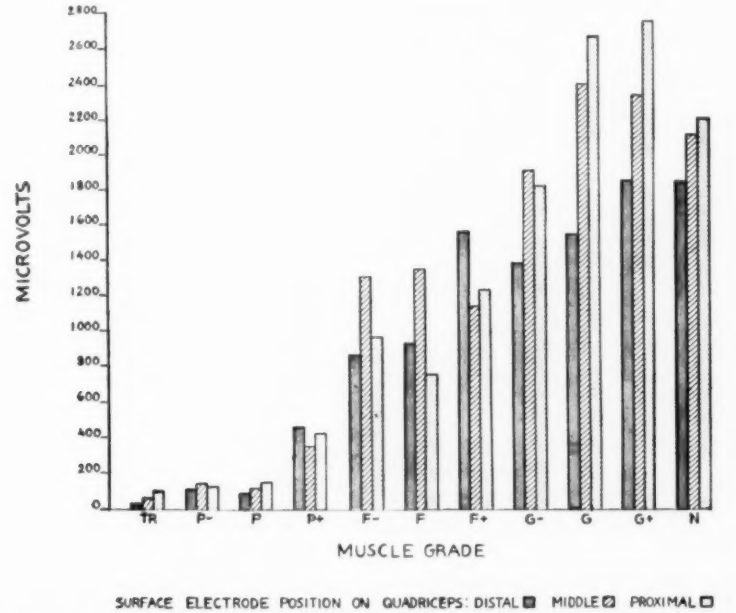

Fig. 5 — A comparison of the average maximal electromyographic voltages recorded from normal and paretic quadriceps muscles.

the graded reflexes within the various levels of quadriceps strength. These findings indicate a progressive decrease and loss of the knee jerk with diminished muscle power. Fifty per cent of those quadriceps rated as good and seventy-five per cent of those rated as good minus had a reflex grade of one. Of those muscles rated as poor plus, seventy-five per cent were without reflexes.

In figure 5, the electromyograms showed the relationship between the voltage generated and the muscle grade; i.e., higher voltages were usually found in those muscles having greater muscle strength. However, the maximal voltages recorded from the three segments of the weakened quadriceps muscles varied in an indefinite pattern for any given muscle grade.

Discussion

Human variation is often a problem in conducting clinical research. Subjects with the same muscle grade differed in their ability to perform the maximal knee extension test. This was true of the normal subjects as well as those having weak quadriceps. When the experiment was repeated on certain individuals it was found that there were changes in their maximal loads and in the microvoltages generated. The changes in maximal peak-to-peak voltage from each electrode position were within one standard deviation of the means of the data from the subject's respective group. The maximal peak-to-peak voltages were not significantly different from the previous test at the same or adjacent electrode positions. However, in one case, when samplings were repeated at each of the electrode positions, the microvoltages from the second trials were significantly greater.

A statistical analysis of the electromyographic voltages as recorded in this study indicates that the electromyogram is a more gross estimate of muscle strength than the manual muscle test.

The indefinite pattern of voltages recorded from the three different segments of the weakened quadriceps muscles here again demonstrates the spotty muscle involvement in anterior poliomyelitis as previously noted by Huddleston and Golseth[1].

During the study, it appeared that the electromyograph as well as being a research tool is a useful device in muscle re-education. Studies are being conducted on the clinical application of the audio system of the instrument in re-education of the accessory muscles of respiration in patients with decreased vital capacity. It was also employed in the strengthening of peroneal muscles in cases of recurrent club feet. Our clinical application of the research instrument is tending to substantiate the work of Knowlton[3] that an electromyograph may be an effective assistive device in muscle re-education.

Conclusions

An investigation was made of quadriceps muscles weakened by poliomyelitis. The findings of this study seem to justify the following conclusions:

There was an appreciable decrease in the knee jerk in the majority of quadriceps muscles with a manual grade of good minus or less.

The patellar reflex was absent in most quadriceps graded at poor plus or lower.

The patellar reflex is not a dependable quantitative measurement of strength in moderately paretic quadriceps.

A reliable manual muscle test remains a finer measurement of quadriceps strength than the electromyographic procedures used in this study.

The relationship between the electromyographic voltages and the manual muscle grades was found to be only qualitative.

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Discussion

Dr. Arthur A. Rodriquez (Chicago): Electromyography as a relatively new diagnostic tool is naturally beset by some growing pains. One of these pains is the tendency to believe that here at last is a medium which provides us with all the answers to all questions heretofore unanswered. Studies and reports such as this one are most welcome because it is as important to know what electromyography cannot do as it is to know what it can do.

The idea that electromyography should be a fine test of muscle strength is based upon some important basic considerations as follows: A muscle in contracting maximally recruits all the available and responsive motor units (spatial summation) and these units discharge at their greatest frequency (temporal summation). A random summation of asynchronously discharging action potentials results, and the so-called interference pattern is the record of this in the normal. Since this phenomenon is directly related to the development of tension by the muscle, it might appear logical at first flush to expect that the amplitude obtained would be an excellent measure of the strength of a muscle. And so it might be were it not for some other facts. These are related to variations in tissue shunt, resistance and electrode pick up areas. In our studies on this same problem, we had an electronic integrator fabricated which permitted us to express the total amount of electrical potential recorded per unit of time. This was very valuable for quantitative comparison of action potential voltages before and after a test procedure when the experiment was performed at the same session.

But as reported in this study, the figures obtained at one session could not be used again for another experiment. It is necessary to set up a control or base line for each experiment.

Electromyography provides far more information than that related to total amplitude of action potential. It tells more about the type and distribution of involvement. But there are also fairly frequent instances where the electromyographic study provides a more accurate assessment of muscle strength than does the muscle analysis. I have seen a muscle graded zero by manual muscle testing, performed by several reliable examiners, which demonstrated the presence of recruitable normal motor units on electromyographic exploration, indicating it could not really be a zero muscle. I have also seen muscles graded as two which, with unipolar electromyography and some quick muscle reeducation brought about by the use of the audio, at the end of the study became a three grade.

Incidentally, as pointed out in this paper, the auditory stimuli accompanying the EMG recording are powerful forces for muscle reeducation.

Manual muscle testing and electromyography are of course complementary methods of study. They are not competetive. This paper adds to the growing knowledge of electromyography and its correlation with muscle grading and reflex changes. It serves to caution us not to expect more from this procedure than we can realistically hope for, and this is good for the proper growth and development of this method.

The Alternating Pressure Pad: An Aid to the Proper Handling of Decubitus Ulcers

W. James Gardner, M.D.
Ruth M. Anderson, R.N.
and
Michael Lyden
Cleveland

Decubitus ulcers (bedsores) are the result of gangrene of the skin due to interference with circulation caused by pressure of the mattress on bony prominences. In their prevention and treatment there is no substitute for good nursing care. The nurse's responsibility is to see (1) that the patient is turned frequently, (2) that threatened areas are massaged, (3) that the bed is dry, and (4) that ulcers are cleansed. For the past six years an alternating pressure pad has been used as an adjunct to these measures at the Cleveland Clinic Hospital. It has proved to be an excellent aid in the proper nursing of these cases.

The alternating pressure pad[1,2] is, in effect, a pneumatic mattress which is placed on top of the ordinary bed mattress. It is made of a plastic, waterproof material with parallel rows of air cells running across its width. Alternate series of these air cells are filled and emptied approximately every three minutes by means of a small electrical pump that operates quietly twenty-four hours a day. The pressure in the inflated series of air cells is sufficient to support the patient's weight while the alternate series of cells is deflated. Viewed from beneath, the patient's skin can be seen to blanch and flush alternately as the air cells inflate and deflate every three minutes. The change in pressure is gradual so that the patient is unaware of movement. The pad is placed on the bed mattress and, in order not to reduce its effect, is covered only by a single bed sheet.

A year of experimentation with this pad convinced the professional and nursing staffs of its value. For the past five years the pad has been used routinely for all patients admitted with decubitus ulcers or who are considered candidates for the development of this condition. The latter group includes paralyzed, comatose, and severely debilitated patients. In addition, it is used in some cases in which turning is painful and also in certain patients who are immobilized by continuous traction or casts. In analysis of our experience, it was found that approximately one patient in twenty-five admissions is treated on the alternating pressure pad.

By use of the pad on patients predisposed to decubitus ulcers it has been possible to keep the skin healthy with the expenditure of half as much nursing time as was previously necessary. When the patient with a decubitus ulcer is treated on the pad, the ulcer heals more rapidly. To evaluate its effectiveness, we have analyzed 100 consecutive cases in which it was used. These patients include 38 who already had a decubitus ulcer and 62 who, without the pad, would have required frequent turning to prevent the appearance of one. These patients spent an average of 29 days on the pad.

Table 1 is an analysis of 38 patients with pressure sores on admission. Of these, 15 showed complete healing, and 19 showed definite improvement of the decubitus. Of the remaining four patients, two died before any improvement

From the Department of Neurological Surgery, The Cleveland Clinic Foundation, The Frank E. Bunts Educational Institute, and the Nursing Division of the Cleveland Clinic Hospital, Cleveland.

Table 1: 38 Patients Having Decubitus Ulcers When Placed on Alternating Pressure Pad

Type of Case	Condition of Ulcer When Patient Discharged		
	Healed	Improved	Unchanged
Hemiplegia	4	4**	—
Paraplegia	—	2	1
Orthopedic cases (either in casts or in traction)	2	3	—
Lupus erythematosus	1	—	1
Metastatic carcinoma	4*	4*	1*
Carbon tetrachloride poisoning	1	—	—
Aortic thrombosis	—	1	—
Ulcerative colitis	—	—	1*
Arthritis	1	—	—
Diabetes mellitus	1	2	—
Severe burns	1	—	—
Uremia	—	1	—
Cerebral arteriosclerosis	—	1	—
Cirrhosis of liver	—	1*	—
TOTAL	15	19	4

Each asterisk denotes a patient who died.

Table 2: 62 Patients Predisposed to Decubitus When Placed on Alternating Pressure Pad

Type of Case	Condition of Patient When Dischared	
	No decubitus	Decubitus present
Hemiplegia	7	
Paraplegia	7	
Quadriplegia	2*	
Orthopedic cases (either in casts or in traction)	5	
Metastatic carcinoma with cachexia	9***	1
Postlaminectomy paraparesis	11	
Postcraniotomy stupor and paralysis	5**	
Severely debilitated medical cases	14*	1*
TOTAL	60	2

Each asterisk denotes a patient who died.

occurred. In neither case did the decubitus become worse. The patient with paraplegia who showed no improvement was hospitalized only four days. The patient with lupus erythematosus whose decubitus showed no improvement was critically ill and during her twelve weeks on the pad developed gangrene of the skin in areas not subject to pressure.

Table 2 is an analysis of a series of patients who were considered candidates for a decubitus. Of the 62, 60 showed no signs of a decubitus at the time of discharge. The position of these patients was changed, as a rule, every four instead of every two hours as would have been necessary without the use of the pad. Estimating a minimum of ten minutes per patient to change his position, one hour of a nurse's time per day per patient was saved for other duties.

In table 2, the patient with metastatic carcinoma who developed a decubitus had a reddened area over the sacrum on admission. Despite frequent turning this area of skin broke down. Although this patient strenuously objected to being turned off his back, the area showed signs of healing when he was discharged to a nursing home fifteen days later. The second patient in whom a decubitus ulcer developed was incontinent and died five days after his admission to the hospital. He was turned frequently, with special back care being given when the first sign of redness appeared. We were unable to prevent this decubitus.

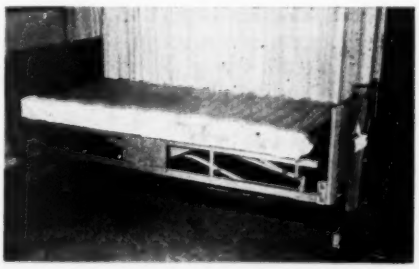

Fig. 1 — The alternating pressure pad is placed on top of the bed mattress and then covered by a single sheet. Inflating tubes lead from a manifold at each edge to the small electric pump on the floor.

The value of the pad is so obvious and the nursing shortage so critical that the policy at the Cleveland Clinic Hospital has been to provide a pad for each patient whose condition demands it. For this reason it was not possible to furnish a parallel control series of patients in which the pad was not used.

Summary

The alternating pressure pad is a useful adjunct in the prevention as well as in the treatment of decubitus ulcers. Its beneficial effect is due to the alternate shifting of the areas of weight bearing, which prevents prolonged ischemia. It has made these patients more comfortable.

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ADDENDUM: Since this article was written, the manufacturer, Air-Mass Inc., has altered the shape of the pad so that the air cells run lengthwise instead of crosswise. This gives a smoother appearance and overcomes the tendency of the pad to creep toward the foot of the bed when the back rest is elevated.

Integrated Plan Returns Patients to Community Life

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According to a report made to the 64th General Assembly of the State of Illinois, 23 per cent of the recipients of state Public Assistance are chronically ill. To aid and speed the economic rehabilitation of Chicago's share of these invalids, the Chicago Department of Welfare, under the leadership of Commissioner A. E. Rose, added a Physical Medicine and Rehabilitation Unit to its Convalescent Service in 1951.* The objective of the new program, as stated in the committee report[1], is "to restore the recipient to the fullest physical, mental, social and economic usefulness compatible with each recipient's abilities and disabilities."

It is the purpose of this paper to describe briefly how this program operates.

The Convalescent Home

The Convalescent Service operates a Convalescent Home on the South Side of Chicago. The Home is housed in a spacious, four-story, solidly constructed, brick and limestone building situated on grounds which occupy half a square block. Provision is made for the physical safety of patients (fire escapes, elevators, handrails, good lighting, etc.) and for their comfort (adequate arrangements for privacy, toilet and bath facilities, as well as insurance against widespread diffusion of noise). The Home is staffed to maintain an active census of 155 patients, although it has a bed capacity of 160. The Physical Medicine and Rehabilitation Unit occupies approximately

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3,000 square feet on the second floor of the Home and is readily accessible to all patients.

The Patients

Patients may be recipients of General Assistance (22 per cent), Categorical Assistance (6 per cent) or Medically Indigent Assistance (72 per cent).

Most come through referral from community hospitals—88 per cent from public and 11 per cent from private—where definitive medical or surgical care has been initiated or completed. One per cent comes by direct referral from family physicians.

Services of the Home

Diagnostic assessment and definitive medical and surgical care are provided by community hospitals. Therefore, these two phases of total rehabilitation are not considered a primary responsibility of the Home. In the light of the general philosophy of the Department of Welfare, the Home is obligated to provide either the remaining services required to complete a rehabilitation program or to make these services available to the patient. These services fall logically into the major phases of total rehabilitation care (other than diagnosis and definitive therapy) as follows: care of specific disability; physical retraining; and psycho, social, and vocational rehabilitation.

All patients undergo a complete physical examination by a staff physician, who determines medical eligibility for admission and orders the necessary medication and nursing care. Prescribed diets are expertly planned by a dietitian whenever indicated. The examining physician also refers patients for physiatric consultation, makes rounds and periodic rechecks, providing skills and treatments to maintain the patient in a maximal state of health. At regular intervals he confers with the physiatrists so that pharmaceutic and physical treatment can be integrated to the greatest advantage of the patient.

Care of Specific Disability

By definition, the period of care of the specific disability is that phase of medical care concerned with minimizing the disability after definitive therapy has been concluded. However, definitive therapy is extended throughout this period as indicated.

To facilitate communication and cooperation between the referring agency and the Home, we depend on our surgical, orthopedic, and medical colleagues for extension of definitive care. Our amputees must frequently be referred to the orthopedist for revision of bad stumps or for surgical release of contractures; patients with polio or nerve injuries are referred for tendon transplants; those with decubiti are referred to the plastic surgeon, and so on.

A physiatrist examines each patient to determine whether he is a suitable candidate for physical treatment and outlines a program of physical medicine designed to reduce the disability to a minimum. The modalities of physical therapy

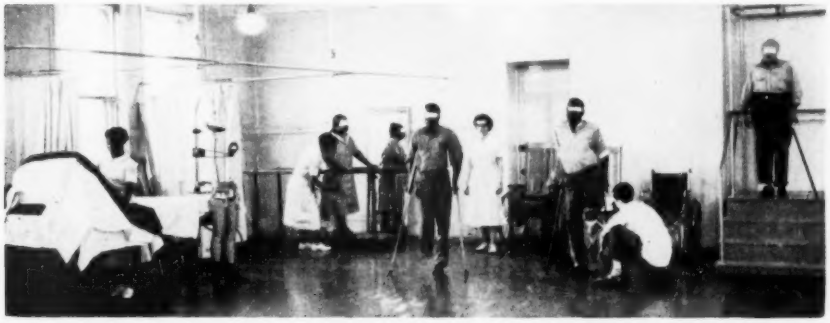

Fig. 1 — Patients undergo various types of modalities in the Physical Therapy Section.

(fig. 1), occupational therapy (fig. 2), and the skills of a Special Apparatus Section (fig. 3) are integrated to give the patient a maximum of effective service. Qualified physical therapists administer the prescribed modalities, which include hydrotherapy, thermotherapy, actinotherapy, massage, therapeutic exercise, electrotherapy, and mechanotherapy. Progress notes are a regular responsibility of the physical therapists.

The occupational therapy section, as recommended by Molander[2], is contiguous to the physical therapy section. As part of the program of physical restoration of affected parts, this discipline, properly prescribed and integrated, has been found most valuable. Its salutary effects on the patients' mental outlook and ability to socialize and adjust to the Home are important benefits. The occupational therapists also keep progress notes in terms of the patients' quantitative improvements.

The Special Apparatus Section is an important part of the Physical Medicine and Rehabilitation Unit. Here, such devices as the knuckle bender[3], hand splints developed at Warm Springs[4], and traction splints applicable to almost any part of the body are fabricated. Another valuable service is that of a chiropodist, who in addition to performing routine care of the feet, works closely with the Physical Medicine Department in preparing special shoe appliances to alleviate many foot problems which disturb ambulation. A program of recreational therapy is also provided to help in directing patients' energies into constructive channels and to make them better adjusted persons. Patients are permitted to participate in games of cards, checkers, picture puzzles, dart games, occasional parties, and to watch movies and television.

Physical Retraining

As Kessler has pointed out[6], the division between the various phases of total

Fig. 2 — In the Occupational Therapy Section, patients' activities are planned to minimize disabilities and strengthen residual capabilities.

rehabilitation of the paraplegic patients is purely imaginary. The same is true with our patients. At any one time, two or more phases of treatment will proceed simultaneously. Nevertheless, such division serves to emphasize the most timely services and helps to assure a systematic and thorough program for each patient.

During physical retraining there is a shift of interests. Instead of concentrating on the patient's specific disorder, his residual capacities are stressed. At the physiatrist's request, an occupational therapist analyzes the patient's activities of daily living according to a list of 117 activities modified after that of Deaver and Brown[6]. An integrated program based on these findings is developed and carried out by various members of the team.

For activities in bed, dressing, undressing, bathing, toilet, grooming, eating, desk activities, and some wheelchair activities, the occupational therapists do the training for the most part. Physical therapists take care of wheelchair, standing, sitting, walking, stair climbing, and traffic activities. The workers in the Special Apparatus Section prepare temporary training pylons[7] and devices[8] to aid in writing, dressing, eating, and other activities. If the patient's physical status permits, conditioning exercises consisting of active and strengthening exercises to uninvolved parts are usually instituted early in this part of the program. Emphasis is placed on strengthening the groups of muscles that will later be called on to perform greater-than-usual efforts. All therapists are cautioned with respect to the danger of the Valsalva phenomenon in elderly patients.

A brace specialist, certified by the American Board for Certification of the Prosthetic and Orthopedic Appliance Industry, Inc., is also an active member of the team. In addition to consulting with the Special Apparatus Section weekly, he is on hand for discussion of

Fig. 3 — Custom-made devices are fabricated in the Special Apparatus Section at the Convalescent Home.

problems with braces and makes needed repairs and adjustments without delay. Braces, as well as artificial limbs, are usually purchased by the Illinois Division of Vocational Rehabilitation, although occasionally other agencies or the Chicago Department of Welfare make the purchase. The manufacturer of artificial limbs also is consulted when necessary.

Psychological, Social, and Vocational Rehabilitation

A social service worker counsels with all patients entering the Home. In broad generalities, she interprets for the patient the purposes and objectives of the Home, what the patient can expect from it, and what is expected in turn from him. As the program develops, the social worker continues her interviews in order to gain maximum cooperation from the patient. Meanwhile, data are accumulated concerning the patient's intelligence, work history, his attitude toward his disability, his aptitudes, interests, and abilities. Psychological testing and pre-vocational and vocational counseling services are provided to all patients as needed. A psychologist from the Department of Welfare Rehabilitation Service administers standard tests which serve as the basis for the setting of realistic targets for each patient.

When schooling is indicated, the Illinois Division of Vocational Rehabilitation arranges for a patient to take standard courses in one of the many recognized schools in Chicago. The Rehabilitation Division of the Chicago Department of Welfare (at another location) provides for its recipients a vocational counseling, retraining, and placement service which patients, health permitting, may attend. By this coordination with other services available in the state and city, the Home may continue to help the patient directly with the transitional problems concerning work, transportation, traffic, and ambulatory activities.

Team Cooperation and Integration

To achieve a "minimum of overlap and a maximum of service in an organized plan designed to bring about maximal recovery in the shortest possible time"[8], frequent staff conferences are held. In addition to the physiatrists, the medical director, chief nurse, administrator, physical and occupational therapists, social workers, vocational counselor, psychologist, chiropodist, and brace specialist attend these meetings. Here new cases are discussed, knowledge is brought together, and objectives are established. Cases are reviewed for re-evaluation and revamping of objectives, and finally, disposition of patients is discussed.

Experience to Date

In the first year of operation, 39.8 per cent of the patients referred to the Physical Medicine and Rehabilitation Unit were treated for the aftercare of fractures and their complications; 15.5 per cent for hemiplegia, and 15.5 per cent for amputations. The remaining complaints were classified as musculoskeletal, central nervous system, peripheral nerve injury, and miscellaneous. The average age of patients was fifty-three years. Educational background of patients has been as follows: 3.2 per cent had a fourth grade education or less; 61.4 per cent, fifth to eighth grade education; 16.1 per cent, one or two years of high school; 3.2 per cent, three or four years of high school; and 16.1 per cent, more than a high school education. These factors of educational levels, plus prior training and skills and social habits, have very often mitigated against achieving desired goals.

Nevertheless, the results have been gratifying. Of the patients completing a program of physical medicine and rehabilitation, 48 per cent have been returned to the community capable of all self-care activities, although they were not capable of being self-supporting; 24 per cent were discharged completely able to support themselves; 9 per cent were referred to nursing home care, and 19 per cent were readmitted for further definitive care in a hospital.

Conclusions

It is difficult to assess the material value of such a program. Through the development of greater physical capacities, undoubtedly many patients who would otherwise have required nursing care have been returned to the community, even though they are not self-supporting. This, of course, represents a saving to the tax payer. The greatest saving, however, was effected by the rehabilitation of the twenty-four per cent of our patients who are now able to support themselves.

If this material consideration were the only measure of the program's value, it would be simple to screen out those patients who are too old, too severely involved, too poorly educated, or who have bad work histories to make treatment "profitable." Only those for whom we could set achievable vocational goals might be admitted. This has not been done; no patient who could benefit even to a small degree has been denied the benefits of this program—which is as it should be.

The philosophy of the Chicago Department of Welfare, so completely in harmony with that of the specialty of physical medicine and rehabilitation in general, was so well expressed in the last paragraphs of the 1946 Decennial Report[9] that it merits quoting: "As we look forward to the years ahead, we firmly believe that any man regardless of race, creed or color anywhere in the world has a right to a decent way of life; that to assist all to that end is not only a fulfillment of a basic responsibility, but prerequisite to the peace, the health and the happiness of the entire community.

The Department of Welfare dispenses no charity. In an abundant society, charity is an anachronism. Rather the Department is an instrument of the people, set up for them and by them, to preserve the dignity of man when he is caught up in circumstances beyond his control, by helping him to help himself."

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Discussion

Dr. Murray Ferderber (Pittsburgh): This report indicates an auspicious beginning for the medically indigent, and frequently chronic case. Too frequently, these are our displaced persons who visit the clinics of our cities and prove the worthiness of reserve left in the human. Unfortunately, we have no method of measuring the physical or vocational reserve of the chronic or the aging individual. Yet, the average was 53 years, which means that many considerably older persons received the benefits of continuing restoration. Here too, one finds the team approach of using all specialties where indicated for the total job. No activity like this can exist or progress without the complete cooperation of all specialties.

However, there are a few gaps in the program requiring some explanation. No mention is made of the family practitioner charged with continuing medical care. All too often, we forget that the

end result of definitive medical care depends upon the practitioner who is the highly important link in the chain of restoration. No method of follow-up is suggested. Here then is a significant item that is not developed in the report.

Reference is made to the statement "twenty-four per cent were returned to the community and were self supporting." Actually, this does not indicate that these patients returned to gainful occupation, but received monies as pensions, public assistance, etc. This may be misleading to readers and should be clarified.

From first hand observation, this novel "convalescent home" without the stigma of "poor house or alms house" should prosper. After its minor problems are resolved, it should be a good demonstration to other governmental agencies. The authors, as well as the parent governmental agency, are to be commended upon their foresight and originality.

The Meaning of "Strength" in Physical Medicine

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The purpose of this paper is to discuss the origin and definition of the word "strength"; to review its usage both in technical and scientific fields; to point out the existing confused variety of meanings used in physical medicine, and to point out the need for the use of unambiguous terms in technical papers.

Physical medicine is rapidly being recognized as a medical specialty based on scientific findings and is developing a technical language of its own with special terms relating to that specialty. A technical language is basic to the development of a science, and terms used must be those which have meaning and understanding and which have a proved relationship to the subject matter with which the terms are concerned. Research can have neither meaning nor add to the advancement of scientific knowledge unless there has been a thorough investigation into and definition of the terms used in the inquiry.

Strength, which comes from the Anglo-Saxon word strengthu, is defined by Webster as "quality or state of being strong; capacity for exertion or endurance, force, power." The Latin word *fortis* and the French *force* mean strength and from them the English *force* is derived. *Force* is defined as "strength or energy, vigor . . . power of effective action." *Power,* which comes from the Latin *posse, potesse,* meaning to be able, is defined as "the ability to act, the capacity for action or being acted upon; capacity of producing or undergoing an effect." *Energy,* from the French *energie* and Latin *en plus ergum* is again defined as the internal or inherent power or capacity of acting. *Energy* is, then, according to Webster, synonymous with power. Thus we see the common definition of *strength* confronts us with four other words: force, power, energy and endurance.

A review of scientific and technical literature reveals that the word strength is rarely used. In all cases reviewed, except in physical medicine, it is qualified. For example *acid strength* in chemical terminology refers to (A) the relative hydrogen ion activity, and (B) concentration as determined by specific gravity.[1,2] In physics we find *tensile*

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strength of matter referring to that point at which matter will pull apart when stretch is applied.[4] *Current strength,* used in physics and physiology, applied to that quantity of electricity which passes a given point in a circuit in one second, the unit quantity of *current strength* being one ampere.[2,5] The *strength-duration curve,* for example, refers to the relationship between the strength and the duration of an electrical current required to produce muscular excitation.[5,6] Technical fields[2,8,9] use the term with a number of adjectives such as "compressive strength," "bond strength," "bearing strength," "impact strength" and "dielectric strength."

The first notation of strength used with medical implication is found in the Oxford Dictionary, 1919 edition; "B. Robinson 1732 Anim. Oecon."—"A frequent Increase of this Force in Muscles much moved must of Necessity increase both their Magnitudes and Strengths." Grinker lists a loss of "general strength" as a symptom of certain neurological conditions.[7]

Although the use of the word *strength* in relation to muscle has not been found in the literature of physiology, chemistry or physics, its usage in the field of physical medicine, especially physical therapy, is widespread. Strength tests have become a part of the evaluation of the effectiveness of treatment methods. In some cases *strength* is the ability of a muscle to resist a breaking *force,* in others, the competence of a muscle to complete a range of motion under given conditions or to perform a particular functional activity. Again, there are *strength tests* in which the speed of movement in relation to work is a factor; or the ability of a muscle to pull against various kinds of resisting forces resulting in either isometric or isotonic contractions.

A review of the *Archives of Physical Medicine and Rehabilitation* and "Physical Therapy Review" from January, 1950 to September, 1953 shows that some twenty-two articles have been written concerning muscular activity under given conditions. Of these articles eleven have the word strength in the title and all twenty-two used the term. Some articles used words such as power, force and strength interchangeably. In some, isometric tension, force and work were measured by springs, cable tension, tensiometer, strain gauge, ergograph, the Beasley myodynometer and the dynamometer, and the results were considered to be measurements of strength. The "dynamometer," by definition, is an instrument which measures force. In other articles, various tests such as the manual muscle tests, the myodynometer break test and De Lorme's one repetition-maximum (1 RM) were criteria of strength.

It is obvious that there is semantic confusion in physical medicine. A definition of those terms which are used as part or all of the word strength and which now have technical meaning of their own, would seem of value in eliminating some of this confusion.

Force is defined as that which produces or stops a motion; changes the velocity or direction of motion. It is either a push or a pull.[4,10] Forces acting about a joint are usually described in terms of torque or the pull (exerted by the muscle) times the distance from the joint center to the muscle insertion.[5]

Tension developed by a muscle is synonymous with the *force* developed by a muscle.

Work is the result of a force causing a load to move and may be expressed as the product of the load by the distance through which the load is lifted. The work a muscle does on a load can be determined experimentally by using either a free-loaded muscle (the load is supported by the muscle at all times) or an after-loaded muscle (the load is supported at all times until the muscle lifts it). The true maximal work is given on theoretical grounds by determining the area under the curve of developed tension in the isometric length-tension diagram.[4]

Power is the rate of doing work. It is determined by multiplying the load by the speed with which the load is lifted. The maximal power of a muscle is de-

veloped when the load is about one-third of the maximal tension the muscle can develop.[6]

Energy is the capacity for work. If energy is active (kinetic) then it is expressed as the product of the mass times the velocity squared ($E=\frac{1}{2}MV^2$). If it is not active, but potential, then it is equal to the work an object is capable of performing by virtue of its position.[4,11]

The relationship between the terms used to denote strength in the articles relating to physical medicine previously mentioned, and the foregoing terms as defined by other sciences, is shown in table 1.

TABLE 1

Terms Used in Physical Medicine*	No. of articles using them	Relationship to terms used in other sciences
Force	1	Measured force
Power	1	Measured isometric tension in various positions
Work	4	Measured work
	1	Measured work, but also spoke of "intensity of contraction"
Strength	5	Measured isometric tension
	4	Measured force
	2	Used terms strength and power interchangeably; measured isometric tension
	1	Used terms strength, power and force interchangeably; measured isometric tension
	1	Used terms strength and force interchangeably; measured isometric tension
	1	Used strength in terms of work and measured work
	1	Used strength in a general way

*Archives of Physical Medicine and Rehabilitation and Physical Therapy Review; January, 1950 through September, 1953.

Analysis of table 1 shows that the largest group of workers (27%) used *work* as a measure of strength, and the second largest group (23%) used *isometric tension*. In reporting their studies only six out of twenty-two authors (or 27%) used terms consistent with that of other sciences and with their own study. If the research being done in physical medicine is to add to the knowledge and understanding of physical medicine and related fields, the terminology used must have an exact and proved relationship to the subject matter with which the terms are concerned. The terms force, power, work, tension and energy have such a relationship and if used as they are defined, then the research will be of scientific value not only to physical medicine, but to biochemistry, physiology and other related sciences.

The preceding argument regarding the confused use of the word *strength* does not mean, necessarily, that the term has no value in the terminology of physical medicine. The term is still useful and necessary where a composite is indicated. But the term should not be used in technical literature particularly in reports of studies dealing with specific aspects of muscular activity. The word strength will have no value in such cases until it has been clearly and unambiguously defined.

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PHYSICAL MEDICINE ABSTRACTS

The Use of Cortisone and Hydrocortisone (Compound F) in Treatment of the Painful Shoulder. Mark B. Coventry. Proc. Staff Meet., Mayo Clin. 29(2):58 (Jan.) 1954.

The causes of painful shoulder are multiple and varied and the treatment used is necessarily dependent on the diagnosis. The use of cortisone should be considered in painful shoulders which have generalized or diffuse involvement, such as in periarthritis. On the other hand, when the condition is localized in a small area of the shoulder, use of hydrocortisone (compound F) is usually a more suitable treatment.

Cortisone should not be used in the treatment of periarthritis of the shoulder until physical therapeutic measures have proved unsuccessful. A week of supervised active exercises, heat and sometimes sedative massage is given to all patients in an effort to evaluate the response. If improvement is noted, cortisone is not used but physical therapy is continued. Even when cortisone is used, physical therapy is continued as before. When most of the pain has disappeared and the patient is showing improvement the use of cortisone may be stopped. The exercises, of course, must be continued until recovery has been achieved.

Hydrocortisone is more suitable for local injection than is cortisone. Hydrocortisone was injected in anticipation of a decrease in nonspecific inflammation due to degenerative or traumatic causes. Results from hydrocortisone must be in the form of a preliminary impression, but to date this method offers as much as and probably more relief than any treatment formerly used.

One must be cautious in evaluating results from any type of treatment used in painful lesions of the shoulder. Many patients spontaneously improve and others may improve simply on injection of procaine.

A Mechanism of the Production of Pseudofractures in Osteomalacia (Milkman's Syndrome). H. L. Steinbach; F. O. Kolb, and R. Gilfillan. Radiology 62:388 (Mar.) 1954.

Osteomalacia is a metabolic disease of bone in which there is deficient mineralization of the bony matrix. The amount of matrix present is normal or slightly increased. The defective deposition of calcium salts is due to the lowered concentration of calcium or phosphorus, or both, in the body fluids, as a result either of impaired absorption from the gastrointestinal tract or increased renal excretion. The bones are weak-

ened, soft, and bend readily. Deformities may occur. Osteoblasts lay down new bone matrix and elaborate alkaline phosphates.

In some cases of osteomalacia, multiple, almost symmetrical, radiolucent bands of diminished density, resembling fractures, occur in the cortex of the bone. These pseudofractures were first described by Milkman.

Arteriograms in a case of osteomalacia with Milkman's syndrome revealed arteries in close proximity to pseudofractures, suggesting that pulsating vessels eroded the cortex. This mechanism would account for the constant, frequently symmetrical, localization of the lesions, their persistence for long periods of time in untreated patients, and their width and smooth margins. In some instances, true fractures may occur in the regions of the cortical grooves because of the weakening of the bone.

Rehabilitation in Rheumatoid Arthritis. Otakar Machek, and Marie Anne Brown. J. Missouri M.A. 51:196 (Mar.) 1954.

In spite of the extensive work done in recent years, the management of the arthritic patient is still a difficult problem. Every year 147,000 persons are disabled by this disease. The advent of hormone therapy did not solve the problem of management and the patient is still faced with the possibility of loss of range of motion and development of crippling deformities. The rehabilitation of the patient should start with prophylaxis. In some cases even the best of care will not prevent contractures. Prophylaxis should include not only preventive measures to maintain good range of motion but those methods which will assure the longest possible remission or arrest of active disease.

In planning a program of rehabilitation, it is helpful to determine the patient's present capacity and future needs. These can be divided into such activities as sleep, self care, travel, work and recreation. Testing these activities helps to evaluate the patient's functional capacity. It is easy to determine the patient's ability to sleep, while the others are appraised by tests of the activities of daily living, including travel. The aptitude for work is tested by a vocational counselor, and includes trials in work therapy. With this information and the medical and social history, the patient's disability can be determined.

The functional capacity evaluation is based on twenty-four hour observations and testing. The physical, mental, vocational, social and economic aspects are considered. Rehabilitation procedures are then planned to augment the remaining abilities, with intermittent rest periods depending on the activity of the disease. These include not only modalities of physical therapy and occupational therapy, but also psychosocial help in adjustment and planning, vocational testing and guidance, and general supportive treatment, including recreation. The last is important in helping maintain motivation.

Physical therapy with its modalities, especially various forms of heat and exercise, is an essential part of the treatment.

Gadgets are made to improve function. Numerous simple and inexpensive adaptations of equipment increase the patient's independence.

Systematic training in activities of daily living is important in achieving personal independence. This is but one facet of a combined treatment in which the dynamic approach is stressed.

Value of Kveim Test as a Diagnostic Measure in Sarcoidosis. Francis J. Rogers, and John R. Haserick. Cleveland Clinic. Quart. 21:79 (April) 1954.

Kveim tests were performed on eighty-eight patients. The tests were positive in forty patients, all of whom had sarcoidosis in a clinically active phase. In four of these, a second test was negative when the disease entered a remission.

The tests were initially negative in six patients with sarcoidosis in a remission or entering it; in two patients with suspected sarcoidosis in a clinically active phase; in one patient with clinically active sarcoidosis entering a clinical remission, and in thirty-seven patients with other diseases.

A positive test was based on the histologic demonstration in the excised test site of a tuberculoid reaction resembling sarcoidosis.

Neurophysiology. Old and New Facts and Theories. Alexander von Muralt. Lancet 1(X):473 (Mar. 6) 1954.

There have been remarkable advances in our knowledge of neurophysiology in the last few years. This is especially true of the knowledge of the process of excitation and of ionic shifts and electrical conduction of nerve fibers. These advances have been made possible through the application of physical and engineering methods by scientists who were biologists, engineers, and mathematicians. These scientists had a predilection for exact measurement and the general concept of the exact scientific method.

Modern neurophysiology began its development in the 18th and 19th centuries. Gravesande was probably the first biologist to recognize an action potential current. He worked in the 1750's on the electric organ of Gymnotus electricus. In 1850, Helmholtz determined the conduction velocity of the nerve impulse. Bernstein in 1863, established evidence of discontinuity of the electric

(continued on page 594)

EDITORIAL

ARCHIVES OF PHYSICAL MEDICINE AND REHABILITATION
OFFICIAL JOURNAL

American Congress of Physical Medicine and Rehabilitation
American Society of Physical Medicine and Rehabilitation

The Prevention and Treatment of Decubiti

The immediate cause of decubitus ulcers is prolonged continuous pressure. Two to three hours of such pressure will usually initiate a bedsore in susceptible tissues. These tissues are found in paralytic states such as paraplegia, in debilitating emaciating diseases such as cancer, advanced rheumatoid arthritis, and tuberculosis, in aged bedfast patients, and in severe traumatic conditions. Even with the best of care, bedsores will occasionally occur.

Few startling advances have been made over the years in the prevention and treatment of decubitus ulcers. As with many other diseases, prevention is of prime importance. It is generally agreed that good general and nursing care are absolutely essential. In the prevention program, the items of importance are: (1) good nutrition; (2) frequent change of position; (3) prevention of skin irritation or damage, and (4) proper conditioning of the skin to increase its resistance.

Good nutrition means a diet which is adequate in all respects, but especially in its protein content. Patients who are susceptible to decubiti are frequently those who have low morale and loss of appetite. Every effort should be made to improve morale and to increase appetite.

Since prolonged continuous pressure is the precipitating factor in decubitus ulcers, frequent change of position is essential. To accomplish this, the patient should be turned every two hours. Just one omission in this regard is likely to produce serious tissue damage.

Prevention of skin irritation may be accomplished by absolute cleanliness. Contamination by the patient's excretions must be prevented by frequent but brief bathing and careful drying. Unnecessarily long contact with water may macerate the skin. Crumbs should be carefully removed from the bed after each meal. Sheets must be kept free from wrinkles. A foot board will support the bedding and allow for a free circulation of air. An air or foam rubber mattress will be helpful in better weight distribution as well as minimize local pressure.

Conditioning of the skin is important in the prevention of bedsores. After each bathing of the vulnerable areas, the skin should be rubbed with alcohol, followed by an application of lanolin, zinc oxide ointment, or cold cream applied with gentle massage. Once daily there should be a twenty or thirty minute application of infrared radiation from a luminous source, followed by graduated doses of ultraviolet radiation. Better still would be daily graduated exposure to sunlight when possible.

When the decubitus ulcer is already present, a vigorous treatment program is necessary. The ulcer should be cleaned with a non-irritating solution, such as physiological saline and dried with luminous heat, after which care-

fully graduated ultraviolet radiation may be applied. Shonyo[1] recommends Carel-Daken solution applied as a wet dressing every three hours for chemical debridement until the ulcer has a clean granulating surface. He has little use for ointments and pastes. He prefers to leave the ulcers open to air and sunlight. It goes without saying that pressure must be removed from the ulcerated area by proper positioning and frequent turning. Absolute cleanliness is of greater importance in the treatment rather than in the prevention of decubiti.

In a controlled clinical study of the treatment of bedsores, Delabarre[2] found that a dressing of liquid adhesive applied over the ulcerated surface produced much more rapid healing than frequently changed gauze dressings. There were no skin reactions to the liquid adhesive, but there were occasional reactions in the control series to the adhesive straps used to hold the gauze dressings in place. The liquid adhesive dressings were changed every three or four days.

Healing of decubitus ulcers can frequently be hastened by skin grafting or plastic surgery. This is especially true of large ulcers in the sacral area and of the burrowing decubiti often seen over the femoral trochanters.

What appears to be an important advance in the prevention and treatment of decubitus ulcers has been presented by Gardner and Anderson.[3-5] For several years they have been using an air mattress which provides constantly alternating pressures to adjacent areas of the patient's skin surface, thus avoiding prolonged pressure on any single area. A description of the alternating pressure pad and the results from its use will be found in this issue of the *ARCHIVES*. Up to the time of the preparation of the report, the authors had used the alternating pressure pad for the prevention of decubiti in sixty-two cases. Only two of these patients developed ulcers. Among thirty-eight patients in whom ulcers were already present, fifteen were healed, nineteen had improved, and four remained unchanged. This report will be of much interest to our readers.

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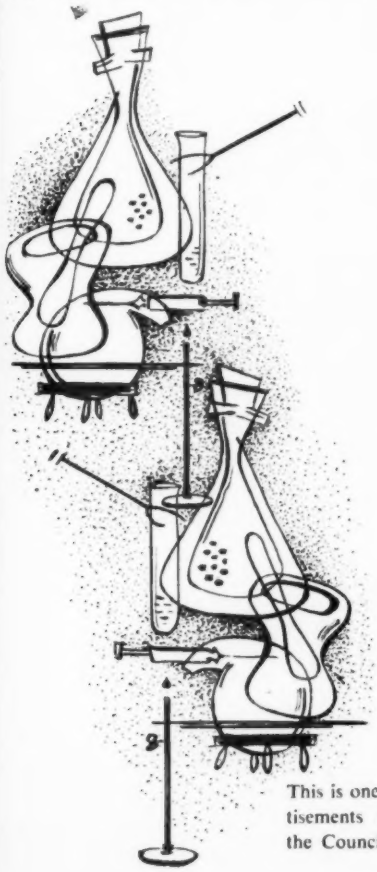

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ABSTRACTS

(*continued from page 590*)

change in the nerve, describing the negativity as propagated in the form of a wave starting from the original point of excitation. He used a differential rheotome and a galvanometer. In 1912 Bernstein put forward the membrane theory, suspecting that differences in ionic concentration are important in the propagation of the electrical wave.

The nodes of Ranvier are the singular points in which excitation is produced in myelinated nerve fibers. The assumption that the internode stores chemical energy available to the excitable membrane at the node is an attractive hypothesis. It has been shown recently that equivalent nodes are present in the central nervous system.

New and strong evidence for saltatory transmission in myelinated nerve fibers has been produced. This has involved ultraviolet light and stroboscopic photochemistry. Chemical events occur in the node at the moment of excitation, and the reactions are very specific, because only the light specifically absorbed by adenosine triphosphate or thiamine, etc., is active.

The free diffusion of potassium ions within the axon and the slow exchange of ions between inside and outside is reliable evidence of a surface barrier and supports the original membrane theory of excitation.

Thus the study of the electric organ, begun in 1750 by Laurens Storm van's Gravesande, has revealed two hundred years later, the full importance of the modern theory of ionic transfer.

Observations on the Antirheumatic and Physiologic Effects of Phenylbutazone (Butazolidin) and Some Comparisons with Cortisone. Bernard B. Brodie, et al. Am. J. Med. XVI (Feb.) 1954.

Phenylbutazone exhibits antirheumatic effects in rheumatoid arthritis which are comparable to those shown by cortisone and corticotropin. The encouraging clinical results obtained should serve to direct further investigation toward other nonsteroidal compounds which may exert desirable local tissue effects without the hormonal imbalance that may accompany the administration of cortisone and corticotropin. At therapeutic plasma levels of butazolidin (50 to 150 mg. per L.) about 98 per cent of the drug is bound to plasma proteins. Because of this affinity, about one-third of a single dose of the drug is localized in plasma. It is rapidly and completely absorbed from the gastrointestinal tract. The peak plasma level is reached two hours after the oral route and six to ten hours after the intramuscular route. Butazolidin behaves in an unusual manner in that plasma levels approach a limiting concentration as dosage is increased. Most subjects achieve plasma levels on 400-600 mg. daily that are only slightly lower than on 800 mg. daily.

Like cortisone the drug causes urinary retention of sodium chloride, water, and may reactivate peptic ulcer; unlike cortisone it does not affect potassium or ketosteroid excretion or cause eosinopenia. Its action is not mediated through the adrenal cortex.

During butazolidin therapy there is often a fall in red cells, hemoglobin, and hematocrit due primarily to hemodilution and not to bone marrow depression.

Retroperitoneal Approach to Lumbar Disc. E. B. Ley, and W. D. Thurston. Rocky Mountain M. J. 51(2):121 (Feb.) 1954.

Retroperitoneal approach for spinal fusion is not new and, in fact, it was advocated by Kellogg Speed in 1917. Some authorities have conceded that anterior fusion is the most efficient fusion of the lower vertebral column because twenty per cent of the patients present spina bifida occulta associated with spondylolisthesis which interferes with proper placement of the graft when the approach is posterior. The transperitoneal approach carries a greater operative risk, but the retroperitoneal approach is not accompanied by shock, does not subject the patient to postoperative intra-abdominal adhesions, and in the authors' experience these patients convalesce as rapidly as an uncomplicated appendectomy.

The indications for this procedure are restricted only to those patients who have minimal protrusion of intervertebral discs. A myelogram should be done as a preliminary procedure to rule out the presence of a neoplasm when clinical findings and conservative management have definitely indicated that surgery is the most desirable treatment. The discogram undoubtedly will make the surgical treatment of degenerated nucleus pulposus a more accurate procedure.

In twenty-five cases the authors have successfully removed a degenerated protruding disc from L-4 or L-5 or both by this approach.

Thermal Burns from the Atomic Bomb. H. E. Pearse, and H. D. Kingsley. Surg., Gynec. & Obst. 98:385 (April) 1954.

The primary burn from an atomic bomb explosion is caused by a brief exposure to high intensity radiant thermal energy, whereas the usual burn seen in civil life is from contact with lower temperatures. How this difference affects the local lesion, its systemic effect, clinical course, and mortal-

ity are not known. Ninety per cent of the Japanese who sought aid in the first week after the atomic bombing did so because of thermal burns, but in view of the confusion there was not a single immediate biopsy available for histologic changes produced in skin.

Thermal burn experiments were done at the detonation of atomic bombs in which animals were exposed behind clear quartz, timing shutters, filters, and fabrics in stations at fourteen different distances to cover from 1.1 to 43 calories per square centimeter. The results ranged from no burn to a char. These animal lesions gave, for the first time, the characteristic gross and microscopic pathology of primary burns from atomic bombs.

No burns were produced in any animal through the filter transmitting only ultraviolet light. The burns received behind filters transmitting visible and infrared rays were about equal in severity. Dark colored animals had a deeper burn than white ones. The burn was found to be caused in the first 1/3 second after detonation. No burns were produced by the initial flash in the first 25 milliseconds. The most severe 0.1 second interval was from 0.1 to 0.2 seconds. The second maximum or "fire ball" created burns equal to exposure to the total thermal pulse. Results indicate that evasive action is of little value.

Dissolution of the Intervertebral Disk in the Aged Normal (The Phantom Nucleus Pulposus). J. Gershon-Cohen, et al. Radiology 62:383 (Mar.) 1954.

Disorganization of the intervertebral disk occurs in association with other degenerative changes. The peculiar "vacuum-like" spaces seen in the roentgenogram as globules in the area of the nucleus or as dispersed radiolucent streaks in the intervertebral space, however, are not generally regarded as a phase of a degenerative process. The authors have described these changes previously as the "phantom nucleus pulposus," and Magnusson and Knutsson have referred to them as intervertebral vacuum phenomena.

A drying out of the disk substance, either as a degenerative change following trauma or as a "normal" aging process seems the best explanation of this phenomena. Aging tissue is said to lose its capacity for retaining water, accounting for the five to six pound weight loss of the body during the seventh decade. The upper dorsal kyphosis so commonly seen in the aged in this group might be the result of these drying-out processes in the spine, with the accompanying relaxation of the paraspinal musculature.

These explanations cannot be applied so readily to the occurrence of the vacuum phenomena during adolescent osteochondrosis as observed by Knutsson. In other studies made by the author, evidence was found of healed osteochondrosis and old herniations of the nucleus pulposus into the vertebral bodies.

Whether this phenomena need be regarded as an irreversible pathologic process rather than a preventable physiologic disturbance is a challenging question.

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BOOK REVIEWS

The reviews here published have been prepared by competent authorities and do not necessarily represent the opinions of the American Congress of Physical Medicine and Rehabilitation and/or the American Society of Physical Medicine and Rehabilitation.

IT'S NOT ALL IN YOUR MIND. By *Hazel J. Berglund*, M.D., and *Herbert L. Nichols, Jr.* Price, $3.95. Pp. 343. North Castle Books, Greenwich, Conn., 1953.

Had the authors confined their observations to allergy, this would have been a pleasing and informative book for laymen. However, their announced intention is to show that organic disease is seldom, if ever, caused by mental states. One-half the text is devoted to allergic conditions. The remaining chapters wander from the workings of the nervous system, components of personality, neuroses and psychoses, dreams, psychoanalysis, internal chemistry, to a pub-crawl among the joints.

The authors offer as "absolute" proof that most diseases have a physical rather than mental origin, in the fact that they elicit measurable physical changes. While denouncing the far-reaching claims of psychosomatic medicine proponents, they avoid the fact that mental stress does cause physical changes, in, for example, measures of adrenal cortical function, thus sidestepping the basic issue of the book.

PATIENTS ARE PEOPLE: A MEDICAL-SOCIAL APPROACH TO PROLONGED ILLNESS. By *Minna Field*. Cloth. Price, $3.75. Pp. 244. Columbia University Press, 2960 Broadway, New York 27; Oxford University Press, Amen House, Warwick Sq., London, E.C.4, 1953.

This book was written by a social worker from the Montefiore Hospital in New York City. This institution pioneered in the concept of the care of the "whole patient," particularly for chronic diseases. The author thoroughly understands the problem from the medical-social aspects and presents many ideas for its solution. The concept of rehabilitation is discussed, in which is brought out the change that has occurred in its goals during the past few years. Many case reports are well presented and illustrate her ideas.

This is a readable book for both laymen and medical personnel. All persons interested in medical rehabilitation will find it valuable.

PARKINSON'S DISEASE AND ITS SURGICAL TREATMENT. By *Leslie C. Oliver*, F.R.C.S. Cloth. Price, $2.50. Pp. 87, with 12 illustrations. H. K. Lewis & Co., Ltd., 136 Gower St., London, W.C.1, 1953.

The author, a neurosurgeon, describes his experiences with approximately 1,000 patients with the Parkinson syndrome, of whom 93 underwent surgery.

The first three chapters provide a brief description of the pathology and etiologic aspects of this disease and its medical management. No mention is made of the use of physical medicine. The author stresses the fact that the majority of patients who have Parkinson's disease should be treated medically, and that operative treatment should not be considered until drugs have been given an adequate trial.

The introduction to the section on surgical treatment emphasizes that surgical procedures have been largely empirical and aimed at relief of the tremor. According to the author, the commonest presenting symptom is disability rather than tremor; therefore, surgical intervention to relieve the tremor when disability is the chief complaint may do more harm than good for the patient.

The discussion of the surgical procedures is divided into cordotomy and intracranial operations. There is a simple description of each operation as well as reports of cases to illustrate the results of the surgical procedures. A brief discussion of orthopedic procedures as well as unsuccessful operations is presented at the end.

The book provides a brief but comprehensive survey of both medical and surgical treatment of Parkinson's disease. The surgeon will find it helpful in selecting the type of operation most helpful for various types of patients with this disease.

BIOCHEMICAL PREPARATIONS. Volume 3. *Esmond E. Snell,* editor-in-chief. Advisory Board: *W. Mansfield Clark* and others. Cloth. Price, $3.50. Pp. 128, with illustrations. John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16; Chapman & Hall, Ltd., 37-39 Essex Street, Strand, London, W.C. 2, 1953.

This manual is the third volume of a series that have been submitted by biochemists active in the field of research. Each preparation has been tested by additional authorities for accuracy.

These are excellent source books for those interested in the preparation and isolation of a number of biochemical compounds.

The laboratory worker will find in this volume instructions for the preparation of twenty-four compounds that are often used in the study of biological functions.

MUSIC THERAPY 1952. Second Book of Proceedings of the National Association for Music Therapy. Volume II. *Esther Goetz Gilliland,* Editor. Cloth. Price, $5.00. Pp. 276. National Association for Music Therapy, P.O. Box 4, Lawrence, Kansas, 1953.

This book is a compilation of papers presented at the Third Annual meeting of the National Association for Music Therapy, held in Topeka, Kansas, October 30-November 1, 1952.

It is difficult to review a book such as this, which represents the ideas of more than fifty authors. Suffice it to say that it serves as a good reference work for those who are interested in the problem of music as an adjunct to medical science. Its greatest appeal will be to those who are interested in psychiatry and psychology, but it should also be of interest to those who are struggling with the problems of rehabilitation in general. It can be recommended for both the extensive coverage of opinion concerning an old art converted into a new science and for the exploration of the possibilities of the use of music therapy as another modality to be used in the treatment of disabilities.

DIURETIC THERAPY. The Pharmacology of Diuretic Agents and the Clinical Management of the Edematous Patient. By *Alfred Vogl,* M.D. Cloth. Price, $5.00. Pp. 248, with illustrations. The Williams & Wilkins Co., Mt. Royal and Guilford Aves., Baltimore 2, 1953.

This volume carries the authenticity of the one who first observed the potential of organic mercurials in the production of diuresis. The work is an extremely comprehensive treatise, covering the total subject of diuretic therapy.

The early chapter headings indicate the content. The indications for diuretic treatment are summarized. The summary of the indications for the use of mercurial diuretics are stated as congestive heart failure, mechanical passive congestion; for therapeutic testing to differentiate pulmonary congestion from bronchitis or bronchiectasis; paroxysmal dyspnea and acute pulmonary congestion from bronchial asthma and asthmatic bronchitis; dyspnea on effort from anginal syndrome; non-cardiac edema, hepatic cirrhosis, nephrotic edema, chronic obstructive edema of the lower extremities; and conditions not associated with edema mentioned but not discussed.

The pharmacology of the various diuretic drugs is elaborated upon, the osmotic diuretics, the acidifying diuretics, the xanthine diuretics, the uracil compounds, decholin organic mineral compounds and an inclusive statement regarding bismuth salts.

The antidiuretics such as the sodium compounds and the various narcotics, sedatives and analgesics, are briefly discussed as a reminder of their effect when of necessity they are utilized in parallel with diuretic therapy.

The most important single cause of fluid retention is backward failure in acute congestive heart failure. However, in more gradual developing decompensation, the renal retention of electrolytes, particularly sodium, is an early and fundamental factor in the development of edema. Though both ions of sodium chloride are retained in cardiac and renal diseases associated with edema, the sodium ion is particularly capable of initiating or increasing fluid retention, since it is the chief determinant of the osmotic pressure of the extracellular fluid. The effect of water in aiding the elimination of sodium and the effect of an acid ash diet in an enhanced diuresis are explained. The Karell diet satisfies the requirements for diminished salt content, but is too low in calories for prolonged use. Dietary adequacy and specific instructions regarding preparation of diet are important items often neglected in practice, particularly which foods to exclude.

Water in diuretic therapy is not restricted. Two to three liters a day represent that which may be expected to give optimal sodium excretion. The use of resin therapy is discussed and the contraindications are given.

Mechanical removal of transudates in the unusual case of cardiac failure with large pleural transudates, ascites and massive edema is considered and the technic elaborated.

There is a complete resumé of the available mercurial compounds for intravenous and intramuscular administration, and the danger of hypersensitive reaction when a more effective and rapid diuresis by the intravenous route is utilized. The subcutaneous

method, when used alternately with other parenteral mercurials, seems approximately as effective, and the fact that it can be injected in the upper extremity is a distinct advantage in many cases. The consistency and inconsistency of oral mercurial therapy is treated. The author feels that in mild chronic congestive failure oral mercurials are justified.

The plan of treatment with mercurial diuretics and the importance of digitalization is discussed at length. Side effects as toxic effects or excessive diuresis are discussed. Absolute contraindication to mercurials exists in the presence of acute glomerulonephritis, anuria, or idiosyncracy to the mercurial itself. The discussion of acidifying salts with special indications for use of ammonium chloride is given. The xanthine diuretics, extremely useful and nontoxic, and the methods of administration receive thoughtful consideration.

Caution during intravenous administration and the use of rectal suppositories as a compromise between the disadvantage of oral administration and the circumvention of parenteral injections are mentioned, particularly the rectal irritation produced. The unpredictability of rectal medication is stressed. The author feels that the xanthine diuretics in combination with mercurials are due for a comeback.

The author's final statement that the advances recorded in this book have in the past decade "pushed back the frontiers of death in congestive heart failure" is a truism.

This rare volume is recommended to the use of all practitioners of medicine as a most comprehensive and adequate accessory handbook of therapy. One-fifth of this work is devoted to bibliography and a well organized index, which add greatly to the authenticity and utility of the publication.

SHOCK AND CIRCULATORY HOMEOSTASIS. Edited by *Harold D. Green*, M.D. Cloth. Price, $3.75. Pp. 275, with 57 illustrations. Josiah Macy, Jr. Foundation. 16 W. 46th St., New York 36, 1953.

The metabolic aspects of shock and the effects of epinephrine and nor-epinephrine are discussed thoroughly in this record of the proceedings of the second conference sponsored by the Josiah Macy, Jr. Foundation. Sufficient illustrations are included to facilitate a better understanding of the text and adequate bibliography added as a reference for those who wish to pursue the discussion or study the sources. The subjects are approached from divergent points of view by representatives of all pertinent basic sciences, as well as clinicians, who comprised the members and guests of the conference.

Careful editorial work has provided a complete and useful index which makes it possible to use the material as a reference for the current concepts in an expanding subject.

The addition of conclusions by the editor might have served to add interest for the casual reader, who does not have time for a complete discussion of details.

HEADACHE. DIAGNOSIS AND TREATMENT. By *Robert E. Ryan*, M.D. Cloth. Price, $6.50. Pp. 338. The C. V. Mosby Company, 3207 Washington Blvd., St. Louis 3, 1954.

Headache is a symptom which is encountered in almost every type of medical practice. In discussing the physiologic basis of head pain, the author points out that pain may originate from the tissues covering the cranium, the cranial periosteum and certain intracranial structures. Among the latter are the 5th, 9th and 10th cranial nerves, the first three cervical, the cerebral and venus sinuses and their tributaries from the surface of the brain. According to the author, the majority of headaches fit into the classification of being vascular in nature.

All headache treatments have two objectives—symptomatic relief of pain and prevention of future attacks. The author places much emphasis on the taking of a complete history in each case. Twenty-six important points in the history taking are listed and the steps in the proper examination outlined. The various specific entities which cause headache, giving etiology, pathology, symptomatology, diagnosis, prophylactic and symptomatic treatment are discussed with an illustrative case history recorded.

The physiatrist will find fault with some rather important omissions. For example, in discussing cervical arthritis, no mention is made of the part played by traction and exercises in the treatment management. Some may argue with his classification. Nevertheless, the author has presented a comprehensive and informative survey of the headache problem with very excellent chapters on migraine, sinusitis and the histaminic headache. This book will be of interest to all physicians including physiatrists.

THE MOTION OF THE HEART: THE STORY OF CARDIOVASCULAR RESEARCH. By *Blake Cabot*. Cloth. Price, $2.00. Pp. 173. Harper & Brothers, 48 E. 33rd Street, New York, 16, 1954.

This book deserves respect not merely because of its earnestness of purpose but also because of the immense amount of first-hand experience it represents. The author has visited innumerable laboratories and clinics to watch experiments and operations. Clear accounts of what he himself has seen are supplemented with accurate details of history.

If the purpose of the book were to instruct the reader in cardiology, it would have been necessary to add diagrams and an index; their absence is likely to be deplored by scientifically inclined readers. Some of the scientists whose work is described will also feel self-conscious and uncomfortable, wondering if the author has succeeded in making their recondite activities look reasonable to the non-medical public. In the opinion of the reviewer, he has succeeded very well. The non-medical public is unfortunately referred to as "laymen" in the preface, contributed by a physician. One cannot help wondering how many chemists, engineers, educators, lawyers, clergymen, and other potential readers are alienated by being referred to as "laymen." As a matter of fact, the amount of up-to-date information on cardiac catheterization, on the use of the ultracentrifuge in the study of atherosclerosis, on the development of intracardiac surgery, and on the relation of adenosine triphosphate to heart failure in this book will make it interesting and profitable reading for any physician, physiologist, or pathologist. It deserves high praise.

NARCOTICS AND NARCOTIC ADDICTION. By *David W. Maurer*, Ph.D. and *Victor H. Vogel*, M.D. Cloth. Price, $7.50. Pp. 303, with illustrations. Charles C Thomas, Publisher, 301-327 E. Lawrence Ave., Springfield, Ill., 1954.

This monograph is a manual concerned with the problem of addiction to narcotic drugs. It is edited by a group of individuals who are concerned with education in the field of public safety. The authors are qualified to write on this subject since they have had much experience in dealing with the problems of addiction.

This book is intended for law enforcement officers and other public officials to provide them with a general knowledge of narcotics and addiction. It does not cover thoroughly the medical aspects of the subject.

The book discusses the nature of drug addiction, various types of drugs that cause addiction and the identification and legal controls of these drugs. There is a section on the treatment of narcotic addiction and the relationship of crime and the specific problems of youth to addiction. The argot of narcotic addicts is well covered. A number of descriptive photographs and tables are included and it has a very excellent bibliography.

The drugs that cause addiction are extremely useful in the practice of medicine. The abuse of these drugs has necessitated the preparation of this text, which is particularly valuable and essential for those who are engaged in all types of law enforcement. It can also profitably be read by those who are engaged in social sciences.

ILLUSTRATED REVIEW OF FRACTURE TREATMENT. By *Frederick Lee Liebolt, M.D.* Paper. Price, $4.00. Pp. 229, with illustrations. Lange Medical Publications, Los Altos, Calif., 1954.

Dr. Liebolt, of the Cornell University Medical College, has compiled a very well illustrated review of the principles involved in fractures. Although in the preface it is stated that the book combines the diagnosis and treatment of fractures, it is the opinion of this reviewer that the text is outstanding for the clarity with which it demonstrates the various types of trauma which produce the more frequently seen fractures.

The illustrations are done in clear ink line drawing and illustrated in almost cartoon-like fashion, showing particularly the effects of indirect and direct trauma on the various bones most frequently injured in accidents.

The text is most useful for medical students, house officers and general practitioners. The study is not intended to be a complete discussion of operative procedures.

In the opinion of the reviewer, the book is ideally designed for those who have frequent recourse to medical-legal problems, in which clear cut discussion of the type of injury often is required. It would also be a valuable book for ancillary medical personnel, such as physical therapists and occupational therapists, particularly because of the excellent illustrations.

THE DOCTORS JACOBI. By *Rhoda Truax*. Cloth. Price, $3.75. Pp. 270. Little, Brown and Company, 34 Beacon St., Boston 6, 1952.

Abraham Jacobi was born of Jewish parents in 1830 in Prussia. His father was a struggling shopkeeper who ruled his household with typical German ruthlessness. It was his mother who pulled him through a rachitic childhood and who spearheaded his medical ambition. He studied at the universities of Greifswald, Gottingen, and finally Bonn, from which he was graduated in 1851. But before he could utilize his medical knowledge, Jacobi spent two years in prison for having participated in the German Revolutionary Movement of 1848. Following his release, he left for England, and soon afterwards for the United States where he settled among the German population of New York City. From the beginning Dr. Jacobi showed an interest in children. His ability and reputation grew so rapidly that in 1858 he became the First Professor of Pediatrics in this country in the newly reorganized New York Medical College.

Mary Corinna Putnam was born in 1842, daughter of George Putnam, the publisher. A pioneer in the study of medicine by women, Mary first studied pharmacy in New York, then medicine in Philadelphia. Not satisfied with her professional attainments, she went to the Paris Ecole de Medicine, where after a considerable effort, she was finally allowed to complete her studies. When the Germans besieged Paris in 1870, Dr. Putnam worked side by side with her male colleagues in the treatment of the sick and wounded. Upon her return to America, her fine reputation resulted in her nomination and election to membership of the New York County Medical Society. She was the first woman doctor so nominated and elected.

This is how the two doctors Jacobi met. As President of the Society Abraham thus welcomed Dr. Mary Putnam into its membership. Their common interest in medicine was a bond which was never to be broken. They were married on July 22, 1873.

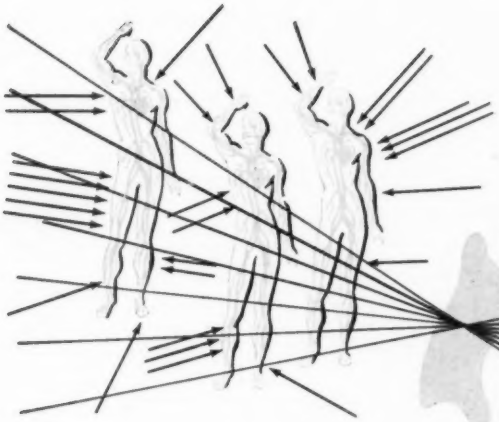
Their lives, hitherto, directed along separate channels, now flowed in unison, although each continued to pursue different medical specialties. Dr. Abraham Jacobi continued his interest in Pediatrics, to which he contributed tremendously. Furthermore he trained many great physicians and surgeons, among his pupils being William H. Welch and William Stewart Halstead. Mary, on the other hand, devoted most of her life to pathology and neurology.

As one reads the book, one gets the feeling that he is reliving his medical school days, for here are portrayed incidents in the lives of some of the great medical pioneers, each of whom at some time or other came in contact with the Jacobis. Interest is considerably enhanced once the two doctors meet, and thenceforth is maintained until the end, that is the death of Abraham. There are some touching scenes in the book.

The "Doctors Jacobi" may be classed as an historical summary of medicine in the last half of the nineteenth century. It will repay the reader's interest.

RADIOACTIVE ISOTOPES, AN INTRODUCTION TO THEIR PREPARATION, MEASUREMENT AND USE. By *W. J. Whitehouse* and *J. L. Putman*. Cloth. Price, $10.00. Pp. 424, with 155 illustrations. Oxford University Press, 114 Fifth Ave., New York 11; Amen House, Warwick Sq., London, E.C.4, 1953.

This book is written by two British scientists, who have been associated from the beginning with the production, measurement and use of radioactive isotopes at the Atomic Energy Establishment in Harwell. It is a comprehensive and yet compact presentation of the important aspects of isotopes, well illustrated, with numerous tables and references. After a short historical introduction on nuclear physics, the authors discuss in detail the application of nuclear reactions to the production of artificial radioactive isotopes, the modes of nuclear disintegration and the properties of various types of radiation. This is followed by the production of isotopes in the graphite and heavy water types of reactors as well as in the cyclotron. An excellent chapter describes detection and measurement of various radiations with Geiger counters, scintillation counters and ionization chambers of a wide variety of construction. Radiation units are introduced and dosage measurements are discussed. The second half of the book deals with a number of applications of radioactive isotopes. This begins with a description of tracer technics, such as the measurement of uptake of iodine-131 in the thyroid gland, of localization of tumors, study of blood circulation, and measurement of blood volume. Examples of radiotherapy with cobalt-60, iridium-192, strontium-90, colloidal gold-198, and phosphorus-32 are given. Technics of autoradiography are presented. Technical uses of radioactive isotopes include studies of friction and lubrication, elimination of static electric charges, radiography with iridium-192, cobalt-60, tallium-182 and antimony-124, thickness measurements of foils or sheets by absorption, dating of archaeological specimens and many others. The concluding chapter on the manipulation of radioactive material, now generally called "health physics," gives many good pointers on construction of safe laboratories and equipment, safe tolerance levels of radiation, shielding against radiation, decontamination, transport and disposal of radioactive material and handling devices for radioactive sources. The book can be highly recommended to all those scientists who work with radioactive isotopes.



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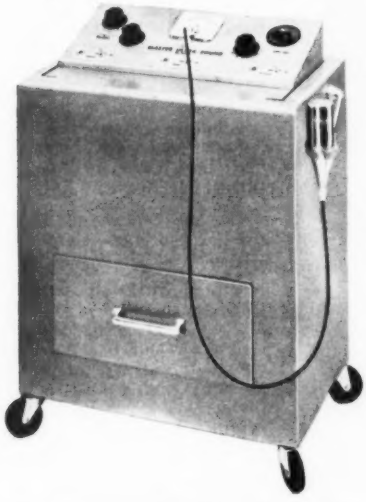

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*Raymond S. Lupse, Youngstown Hospital Association, Youngstown, Ohio, In Press.

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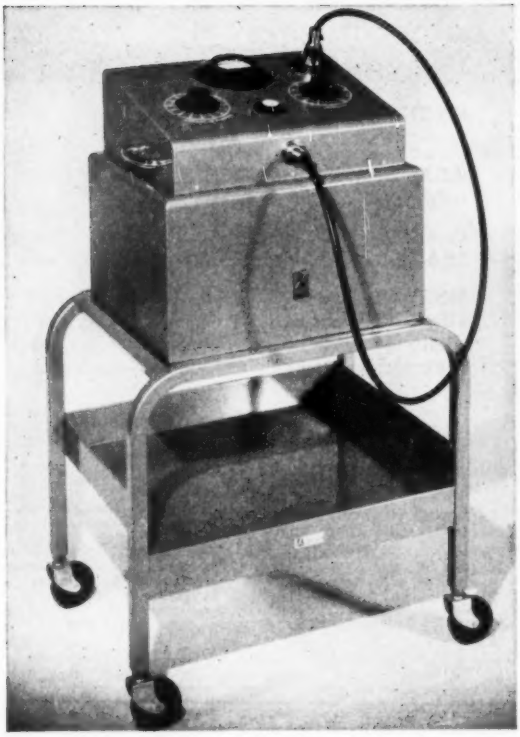

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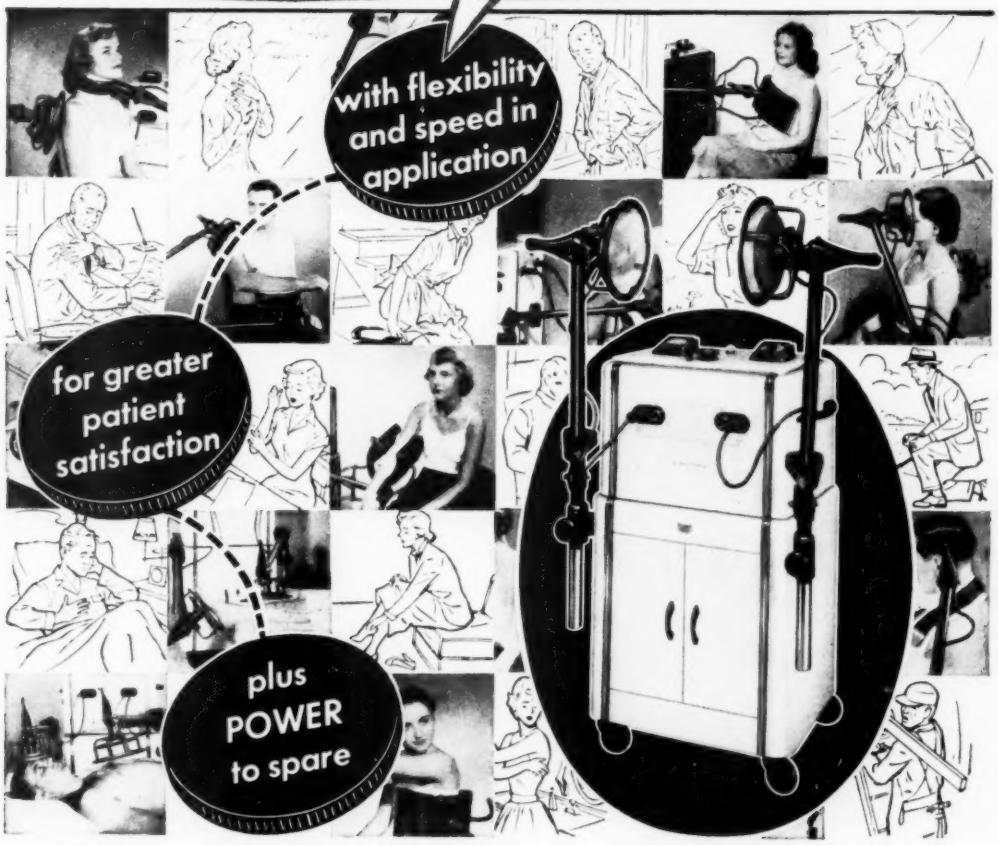

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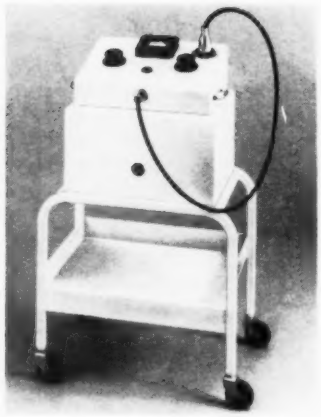

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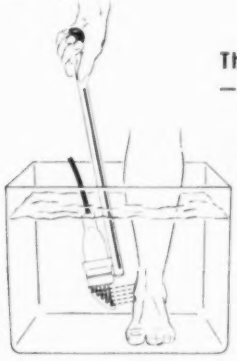

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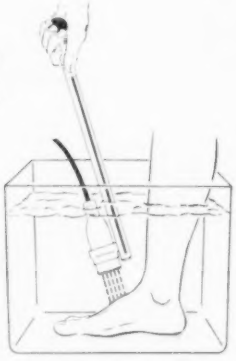

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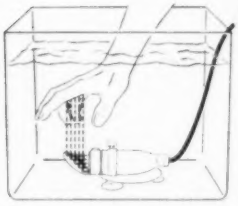

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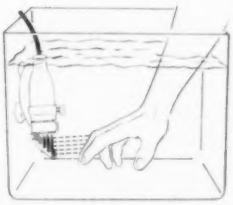

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